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# FIELD MOISTURE CONTENT INVESTIGATION

## NOVEMBER 1952 - MAY 1956 PHASE



TECHNICAL MEMORANDUM NO. 3-401

Report 3

May 1961



U. S. Army Engineer Waterways Experiment Station  
CORPS OF ENGINEERS  
Vicksburg, Mississippi

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- 1. Airport runway base courses
- 2. Soils-moisture content
- 3. Subgrade

1. Vroman, L. M.  
II. McNamee, M. J.  
III. Fry, J. S.  
IV. Waterways Experiment Station, Technical Memorandum No. 3-601, Report 3

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U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss. FIELD MOISTURE CONTENT INVESTIGATION, NOVEMBER 1952-MAY 1956

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ARMY-MRC VICKSBURG, MISS.

## PREFACE

The investigation reported herein was made in accordance with "Instructions and Outline for Field Moisture Content Investigation," dated 5 February 1945, and addenda 1 through 14 thereto, and "Instructions and Outline, Engineering Investigations for Flexible Pavements, U. S. Army Engineer Waterways Experiment Station," FY 1958, 1959, and 1960, inclusive, and is a continuing study conducted by the U. S. Army Engineer Waterways Experiment Station for the Office, Chief of Engineers.

The field work was accomplished by personnel of the Waterways Experiment Station under the general supervision of Mr. W. J. Turnbull, Chief, Soils Division, and Messrs. C. R. Foster (formerly of the Waterways Experiment Station), A. A. Maxwell, and O. B. Ray. This report was prepared by Messrs. L. M. Womack, M. J. Mathews, and Z. B. Fry.

Directors of the Waterways Experiment Station during the conduct of this study and preparation of this report were Col. H. J. Skidmore, CE, Col. C. H. Dunn, CE, Col. A. P. Rollins, Jr., CE, and Col. Edmund H. Lang, CE. Technical Director was Mr. J. B. Tiffany.

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## SUMMARY

Tests were conducted on base course and subgrade materials at Kirtland AFB, Albuquerque, N. Mex., Sewart AFB, Nashville, Tenn., and Craig AFB, Selma, Ala., located in different climatic regions, to determine the variation in moisture content with time, and the movement and source of moisture beneath airfield pavements. Test sites at each field were located near the center line, quarter-point, and edge of a paved facility and on the shoulder area. Tests were performed and samples obtained at the surfaces of the base course and subgrade, and 18-in. depth in the subgrade at varying intervals, normally every three to six months. Field tests consisted of in-place moisture, CBR, and density determinations. Tests performed on samples in the laboratory involved determination of sieve analysis, Atterberg limits, specific gravity, and moisture-density-CBR relations (modified AASHTO compaction test). Computations were also made to determine the percentage of saturation of the materials.

The variation in moisture content with time (all elevations) followed no prescribed pattern of increase or decrease. The 18-in. depth in the subgrade was the only elevation to produce a trend of higher moisture content in the high rainfall zone. The variation (movement) of moisture content across the pavement width was insignificant in the base course and inconsistent for the two elevations in the subgrade.

In-place moisture contents varied directly with the soil's plastic limit, liquid limit, plasticity index, optimum moisture content, and percentage of material passing the No. 200 sieve.

The moisture contents and CBR values of laboratory soaked samples (used to predict the worst future condition of the material) were generally conservative compared to the values obtained in the field for base courses, and were conservative in comparison to or approximated those obtained for subgrade materials.

The variation in moisture content could not be directly related to rainfall zone or climatic region, nor was the source of the moisture definitely determined for the areas tested.

## FIELD MOISTURE CONTENT INVESTIGATION

NOVEMBER 1952-MAY 1956 PHASE

### PART I: INTRODUCTION

#### Background, Purpose, and Scope of Study

1. This report is the third of a series on the study of moisture conditions in base courses and subgrades under flexible airfield pavements. The first report\* dealt with the investigation of the Bouyoucos moisture cell as a possible means for measuring soil moisture. The investigation showed that the cells available at that time were not satisfactory for use under flexible pavements; therefore, a direct-sampling method was adopted for determining moisture content in all ensuing investigations. The second report\*\* describes the results of the moisture content investigation from October 1945 to November 1952 in which the direct-sampling method was first used. This report (Report 3) describes the November 1952 to May 1956 phase of the investigation, and together with Report 2 completes the presentation of data obtained by direct or in-situ sampling methods on the accumulation and movement of moisture in soils beneath certain airfield pavements.

2. In conjunction with this study, other means of measuring and recording the moisture in soils have been investigated, namely Colman moisture cells. These cells, Fiberglas units by which electrical resistance is determined, have been installed since October 1955 in a test section at the U. S. Army Engineer Waterways Experiment Station (WES). The results obtained from this test section will be published in a subsequent report.

3. Another method considered applicable to a study of this nature has been investigated and developed by the Road Research Laboratory, Department of Industrial and Scientific Research, England. This method

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\* U. S. Army Engineer Waterways Experiment Station, CE, Field Moisture Content Investigation, Interim Report 1 (Vicksburg, Mississippi, May 1948).

\*\* \_\_\_\_\_, Field Moisture Content Investigation; October 1945-November 1952 Phase, Technical Memorandum 3-401, Report 2 (Vicksburg, Mississippi, April 1955).

involves the use of tensiometers and the determination of pore-water pressure, soil suction, and the compressibility factor. The results of the study\* show excellent correlation between predicted and actual, measured moisture contents; this correlation, however, is largely dependent on a relatively high water table. It is believed that this method of approach should be studied further, particularly in regard to its application in areas of low water table.

4. As described in the previous reports of this series, the general objectives of the field moisture content investigation are to determine the sources of water in soils under flexible airfield pavements and the extent to which these soils become wet after completion of pavement construction. To accomplish these objectives, it was necessary to investigate the following items:

- a. Moisture gradients across the pavement width at three elevations in the base course and subgrade.
- b. Effect of surface and subsurface drainage systems on moisture conditions under pavements.
- c. Extent and rate of capillary movement of moisture under pavements.

5. The permeability of pavements was also being investigated in connection with a study of the resistance of pavements to jet-fuel attack. A study to determine the amount of condensation under pavements was held in abeyance until a satisfactory meter for measuring moisture contents could be found. This study has been made using Colman Fiberglas moisture cells, as mentioned in paragraph 2, and will be discussed in a separate report.

#### Airfield Sites Investigated

6. It was desired that the field moisture investigations be conducted on airfields located in arid, semiarid, and humid regions and that each field have a different type of subgrade material. Data presented in previous reports of this series were obtained from the following airfields:

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\* W. P. M. Black, D. Croney, and J. C. Jacobs, Field Studies of the Movement of Soil Moisture, Road Research Laboratory Technical Paper 41 (Harmondsworth, Middlesex, England, 1958).

Kirtland AFB, Albuquerque, N. Mex.  
Santa Fe Municipal Airport, Santa Fe, N. Mex.  
Clovis AFB, Clovis, N. Mex.  
Bergstrom AFB, Austin, Tex.  
Goodfellow AFB, San Angelo, Tex.  
South Plains AFB, Lubbock, Tex.  
Memphis Municipal Airport, Memphis, Tenn.  
Keesler AFB, Biloxi, Miss.  
Craig AFB, Selma, Ala.  
Vicksburg Municipal Airport, Vicksburg, Miss.  
WES Test Section, Vicksburg, Miss.

Airfields from which data are presented in this report are:

Kirtland AFB, Albuquerque, N. Mex.  
Craig AFB, Selma, Ala.  
Sewart AFB, Smyrna, Tenn.

Limited data from the previous reports are included herein where necessary as background information or to establish indicated trends of moisture conditions under flexible pavements.

## PART II: THE INVESTIGATION

Fields Studied

7. Average annual rainfall and base course and subgrade classifications for the airfields studied in the November 1952-May 1956 phase of this investigation are listed below:

<u>Field</u>	<u>Avg Annual Rainfall in.</u>	<u>Unified Soil Classification</u>	
		<u>Base</u>	<u>Subgrade</u>
Kirtland AFB	Below 15	GW	SM-SC
Craig AFB	Above 35	SC	SC
Sewart AFB	Above 35	GW	CH

The following paragraphs present additional information on physiography, soil formation, ground-water table, and climate for each of these airfields.

Kirtland AFB

8. Kirtland AFB is located physiographically in the Open Basin section of the Basin and Range province on the down-fault side of the Sandia Mountains about eight miles from the point of uplift. The general area in which the airfield is located is about 5000 ft above sea level. Natural soils at the site are gravelly sands which contain some caliche near the surface. The true ground-water table is at a depth of more than 100 ft. The climate is dry, with an average annual rainfall of about 8 in. Maximum and minimum temperatures of record are 104 and -10 F; temperature variations from night to day are generally large. The natural topography of the airfield site is relatively flat; after a rain some water ponds between the runways and taxiways for a short time. However, the drainage system is considered generally satisfactory, shoulder slopes are satisfactory, and water does not pond at the edges of the various pavements. All runway and taxiway facilities are flexible-type pavements.

9. The particular site (designated site 2) selected for this phase of the field moisture content investigations at Kirtland AFB is located on the west end of taxiway 8. This taxiway is parallel to and north of the E-W runway and taxiway 2, which were the sites of the previous field moisture investigations at the airfield. The flexible pavement structure of

taxiway 8 consists of 4 in. of hot-mix asphaltic concrete, 7 in. of gravel-sand (GW) base course, and 18 in. of compacted clayey sand (SM-SC) or silty sand (SM) subgrade. The base course material is nonplastic whereas the plasticity index of the subgrade material ranges from nonplastic to 8. The surface of the flexible pavement was in good condition.

#### Craig AFB

10. Craig AFB is located physiographically in the East Gulf Coastal Plain section of the Coastal Plain province at an elevation of approximately 150 ft above sea level. Natural soils in the general area consist of sand, silty sand, clayey sand, and gravelly sand. In the test area the subgrade material is a silty sand extending at least to the water table, which was at a depth of 7 ft at the time of this investigation. The climate is humid and mild, average annual rainfall is about 50 in., and maximum and minimum recorded temperatures are 106 and -5 F. The nearby hills provide good natural drainage for the field. Ponding of water occurs near the edges of some of the Craig AFB facilities because of rutting of the shoulders by traffic and also because of grass growing over the pavement edges. All facilities are paved with asphaltic concrete.

11. The site (site 2) selected for this phase of the field moisture content investigation is near the southeast end of the south NW-SE runway. The flexible pavement structure consists of 2 in. of hot-mix asphaltic concrete and 9 in. of a clayey gravelly sand (SC) base course on a compacted sand subgrade (SM-SC). The plasticity index of the base course material ranges from 11 to 23 and that of the subgrade from nonplastic to 20. Cracks and ruts were noticed over the entire field early in 1952, some of which were in the test area. During the period of this investigation (1952-1956), no progression of the pavement distress in the test area was noted. Indications were that the distress was due to shear deformation in the base course.

#### Sewart AFB

12. Sewart AFB is located physiographically in the Nashville Basin section of the Interior Low Plateau province at an elevation of approximately 510 ft above sea level. The general terrain in the area is characterized by small, rocky hills or "glades." Some areas feature high pinacles and low valleys. Numerous limestone outcroppings are in evidence, and

during construction of the field some sinkholes and springs were encountered. The subsoil in the area is composed of clays that classify generally as CH. Temperatures at the site vary widely with an average of 60 days per year having temperatures below freezing and an average of 38 days per year having temperatures above 90 F. Average annual precipitation amounts to about 50 in., which includes a moderate amount of snowfall. Practically all runoff from the airfield is conveyed by two main drainage systems into nearby Stewarts Creek, a tributary of Stones River. The drainage system is performing satisfactorily.

13. The site selected for the field moisture content investigation is near the northwest end of the NW-SE runway. The flexible pavement structure consists of 4 in. of asphaltic concrete and 12 in. of crushed limestone base (GW) over a subgrade material of red fat clay (CH) and minor amounts of silty clay (CL). The base course material is nonplastic, and the plasticity index of the subgrade material averages about 37. The general condition of the flexible pavement was good at the time of this phase of the study.

#### Test Program

##### Test locations

14. Test locations similar to those shown in plate 1 were investigated at each of the fields. These test locations were in areas where the pavement appeared to be in good condition and drainage conditions were about average for the field. They were divided into two groups: (a) the "normal" locations (1-3, plate 1) where pavement is maintained in its normal condition, and (b) the "shoulder" location (4, plate 1) on the unpaved shoulder.

##### Tests conducted

15. Four sets of tests were performed at each normal and shoulder location at the time of each testing. The tests were performed in holes approximately 10 in. in diameter with one hole located in each quadrant (see pattern of test holes, plate 1). At each testing the holes were located adjacent to the last holes tested previously, in a pattern of concentric circles. At the time of the initial testing of each field,

in-place moisture content, density, and CBR determinations were made in large test pits about 15 ft from each of the normal and shoulder locations. In addition, disturbed samples of the pavement, base course, and subgrade materials were obtained from these pits for laboratory testing. Tests performed at each elevation in the test pits were as follows:

<u>Elevation</u>	<u>Tests Performed</u>
Surface of base	Moisture content, density, CBR
Surface of subgrade	Moisture content, density, CBR
18 in. below surface of subgrade	Moisture content

Tests were performed at the surfaces of the base and subgrade because it was felt that this elevation was the most critical in each layer. Tests were also made at a depth of 18 in. in the subgrade in order to compare moisture conditions at two elevations in the subgrade. Each field was visited two to four times a year, and attempts were made to test each field under various seasonal conditions.

16. Atterberg limits, gradation, specific gravity, and moisture-density-CBR relations of base course and subgrade materials from the various fields were determined in the laboratory. Samples of the bituminous pavement were tested, and the unit weight, stability, flow, and voids relations determined. In addition, representative samples were subjected to extraction tests to determine the asphalt content, and the gradation and specific gravity of the extracted aggregate were determined.

#### Presentation of Test Data

17. The following paragraphs outline the arrangement of tables and plates by subject matter in this report and their order of presentation. The tables and plates will be discussed in detail later in the report.

#### Tables

18. The average values of CBR, density, moisture content, percentage of saturation, and soil characteristics obtained at each test location at each testing are shown for the three fields in tables 1, 2, and 3, respectively. Results of laboratory tests on samples of the base course and subgrade materials from all three fields are presented in table 4, and the results of tests on pavement samples in table 5. Pertinent rainfall

data are shown in table 6. Construction data presented in table 7 were obtained either from control-test records or from records of special tests performed immediately after the completion of construction. In most cases the values shown in table 7 are averages of a number of results obtained in the immediate area in which the field moisture tests were conducted. However, in a few instances data were not available for the immediate area of testing, and averages were taken for rather large areas at some distance from the point at which the field moisture tests were performed.

#### Plates

19. As mentioned earlier, the pattern of test locations at the airfields investigated is shown in plate 1. Gradations of base course and subgrade materials are shown in plates 2 and 3, respectively. Results of Atterberg limits tests on base course and representative subgrade surface materials are shown in plates 4 and 5, respectively. Results of laboratory tests to determine the moisture-density-CBR relations on base course and subgrade samples from the three fields investigated are shown in plates 6-11. Plates 12-20 present plots of the variation in moisture content, percentage of saturation, and CBR with time at the various test locations at each of the airfields. Moisture content values for each sampling at each of the test locations (normal and shoulder) are shown in plate 21. By joining these points with straight lines a moisture distribution profile across the width of the pavement is shown. Similar profiles of density, CBR, and degree of saturation are presented in plates 22, 23, and 24, respectively. Other relations of moisture content versus Atterberg limits, soil gradation, annual rainfall, degree of saturation, and CBR are plotted in plates 25-43.

### PART III: ANALYSIS AND DISCUSSION OF DATA FROM INDIVIDUAL FIELDS

20. Pertinent data concerning each airfield, and a comparison of conditions at the different test locations at each field, as indicated by the test values obtained, are presented in the following paragraphs. These comparisons are based on the test results summarized in tables 1-5. The degree of saturation has been found to change with changes in moisture content, which in turn varies with time and location, and may also change with density which has been found to change mainly with location and very little with time; therefore, the degree-of-saturation values could vary with time and are considered to do so in the analysis. Density values are not considered as changing with time.

#### Kirtland AFB

21. The test data obtained at Kirtland AFB are shown in table 1 and plots of moisture content, degree of saturation, and CBR data versus time are shown in plates 12-14. Qualitative comparisons of conditions at normal and shoulder locations based on the tabulations and analyses of the data obtained at Kirtland AFB are made in the following tabulation.

<u>Course</u>	<u>Normal Location</u>	<u>Shoulder Location*</u>
<u>Moisture Content</u>		
Base	Slight decrease with time	
Subgrade surface	Variation with time, slight decrease indicated	Variation with time; lower than at normal locations
Subgrade, 18-in. depth	No trend, slight variation with time	Variation with time, but no general trend
<u>Degree of Saturation</u>		
Base	Slight decrease with time	
Subgrade surface	Decrease with time	No trend; lower than normal locations
Subgrade, 18-in. depth	No data taken	
(Continued)		

\* Depth below ground surface at shoulder location equal to depth below pavement surface at normal location.

<u>Course</u>	<u>Normal Location</u>	<u>Shoulder Location</u>
<u>CBR</u>		
Base	General increase, variation with time	
Subgrade surface	General increase	No trend
Subgrade, 18-in. depth	No data taken	

Craig AFB

22. The test data obtained at Craig AFB are shown in table 2, and plots of the moisture content, degree of saturation, and CBR data versus time are shown in plates 15-17. Qualitative comparisons of conditions at normal and shoulder locations are made in the following tabulation.

<u>Course</u>	<u>Normal Location</u>	<u>Shoulder Location</u>
<u>Moisture Content</u>		
Base	No trend	
Subgrade surface	Slight decrease	Variation with time, slight decrease
Subgrade, 18-in. depth	Slight decrease	Slight decrease; higher than normal locations
<u>Degree of Saturation</u>		
Base	Slight increase	
Subgrade surface	No trend	Slight decrease, variation with time
Subgrade, 18-in. depth	No data taken	
<u>CBR</u>		
Base	Variation with time, no trend	
Subgrade surface	Variation with time, slight increase	No trend, variation with time
Subgrade, 18-in. depth	No data taken	

Sewart AFB

23. The test data obtained at Sewart AFB are shown in table 3, and plots of moisture content, degree of saturation, and CBR data versus time

are shown in plates 18-20. Qualitative comparisons of conditions at normal and shoulder locations are presented in the following tabulation.

<u>Course</u>	<u>Normal Location</u>	<u>Shoulder Location</u>
<u>Moisture Content</u>		
Base	Variation with time, no trend	
Subgrade surface	Variation with time, no trend	Variation with time, no trend
Subgrade, 18-in. depth	Variation with time, no trend	Variation with time, no trend
<u>Degree of Saturation</u>		
Base	Variation with time, no trend	
Subgrade surface	No trend	Variation with time, no trend
Subgrade, 18-in. depth	No data taken	
<u>CBR</u>		
Base	Variation with time, slight increase	
Subgrade surface	Variation with time, slight increase	Variation with time, no trend
Subgrade, 18-in. depth	No data taken	

## PART IV: GENERAL ANALYSIS AND DISCUSSION

24. Pertinent data from the 1945-1952 phase of the field moisture content investigation and data from the fields studied in this (1952-1956) phase are analyzed as a whole in the following paragraphs. Data from the previous investigation are included so that positive or negative trends may be substantiated. Factors that may possibly affect moisture conditions and which were investigated in the earlier phase of the investigation and continued during this phase of the investigation are discussed, followed by discussions of changes in moisture content, degree of saturation, and CBR values with time. As indicated previously, density is not considered as varying with time but will vary with location. Variations occurring with time are analyzed with respect to both the individual points tested and the flexible pavement cross section. Soil characteristics, rainfall, and design requirements are the basis of the analyses in the latter portion of this part.

Drainage

25. The adequacy of the surface drainage at each test site and the depth to the water table were discussed in Part II. These factors are summarized in the following tabulation for each field investigated as well as for those fields investigated during the 1945-1952 phase and used again in this analysis. In Report 2 it is explained that drainage is classed as good when: (a) the pavement has a surface free of depressions and is sloped to drain to the shoulders, (b) the shoulders are sloped to drain away from the pavement, or (c) water is not ponded at the pavement edge by vegetation or soil. Drainage is classed as poor when: (a) the pavement surface contains depressions, (b) shoulder slopes are such that satisfactory runoff is not obtained, or (c) water is ponded at the pavement edge as a result of vegetation or high shoulders.

<u>Field</u>	<u>Surface Drainage</u>	<u>Depth to Water Table, ft</u>
Santa Fe	Generally good	100+
Clovis	Good	100+
Bergstrom	Good	Approximately 20

(Continued)

<u>Field</u>	<u>Surface Drainage</u>	<u>Depth to Water Table, ft</u>
Goodfellow	Good	Estimated 50+
South Plains	Generally good	80
Memphis	Poor	---
Keesler	Good	3-6
WES test section	Poor	100+
Vicksburg	Poor	5-6
Kirtland, site 1, 1945-1952	Good	100+
Kirtland, site 2, 1952-1956	Good	100+
Craig, site 1, 1945-1952	Good	7
Craig, site 2, 1952-1956	Poor	7
Sewart	Good	Not available

Variations in Moisture Content, Saturation, and CBR  
with Time at Individual Test Locations

26. The variations in moisture content, degree of saturation, and CBR with time are generally within certain ranges; however, within these ranges certain variations occur that are attributed to climatic changes. Although analyses have been made of the variation in conditions with time, it is recognized that the elapsed time between samplings may have been too great to insure a straight-line variation between plotted points. In analyzing the general trends, the slopes of the lines connecting any two consecutive points are not considered, rather the values are considered to have increased or decreased when an average line drawn through the points has either a general upward or downward trend. Shoulder locations are not considered in the general analysis, since data obtained at such locations vary depending on whether or not rain occurred immediately prior to the time of testing.

27. Plots of moisture content, degree of saturation, and CBR versus time for the base course and for the two depths in the subgrade at the various locations tested are shown in plates 12-20. Summaries of the trends indicated by the plots are tabulated in the following paragraphs to show the variations with time at the respective locations. In summarizing these data, the time versus moisture content, saturation, and CBR plots are described as (a) "increasing" when there is a continued trend for values to increase with time, (b) "decreasing" when there is a continued trend for values to decrease with time, (c) "not significant" when the change in

values over the entire period is very small and follows no trend, and (d) "not continuous" when the change is appreciable but follows no continuous pattern.

#### Base course

28. The plots of base course values versus time are shown in plates 12, 15, and 18, and may be summarized as follows:

<u>Field</u>	<u>Rain-fall Zone*</u>	<u>Classification of Base</u>			<u>Trend of Moisture with Time</u>	<u>Trend of Saturation with Time</u>	<u>Trend of CBR with Time</u>
		<u>LL</u>	<u>PI</u>	<u>Symbol</u>			
Kirtland	-15	--	NP	GW	Not signif	Decreasing	Increasing
Craig	+35	31	16	SC	Not signif	Increasing	Not signif
Sewart	+35	--	NP	GW	Not signif	Not signif	Not signif

\* -15 denotes low rainfall zone, i.e. average annual rainfall less than 15 in.; +35 denotes high rainfall zone, i.e. average annual rainfall more than 35 in.

This summary indicates that for the base course materials: (a) only a very small change in moisture occurred and it followed no particular pattern or trend, (b) changes in degree of saturation with time followed no particular pattern (comparable data in Report 2 also indicate no general trend), and (c) changes in CBR with time followed no particular pattern (as was also shown in Report 2). In addition, changes in degree of saturation and CBR could not be related to rainfall zone or plasticity of base course material.

#### Subgrade surface

29. Plots of subgrade surface values versus time are shown in plates 13, 16, and 19, and are summarized below:

<u>Field</u>	<u>Rain-fall Zone</u>	<u>Classification Subgrade Surface</u>			<u>Trend of Moisture with Time</u>	<u>Trend of Saturation with Time</u>	<u>Trend of CBR with Time</u>
		<u>LL</u>	<u>PL</u>	<u>Symbol</u>			
Kirtland	-15	21	4	SM-SC	Decreasing	Decreasing	Increasing
Craig	+35	24	11	SC	Decreasing	Not signif	Increasing
Sewart	+35	56	34	CH	Not signif	Not signif	Not signif

This summary indicates that for the surface subgrade soils: (a) moisture content showed a decreasing trend, (b) no general trend in degree of saturation with time was apparent (this is substantiated by comparable data in Report 2), and (c) changes in CBR values followed no particular pattern (also borne out by Report 2). No relations are indicated between changes

in degree of saturation or CBR and rainfall zone or plasticity of the subgrade materials.

Subgrade, 18-in. depth

30. Moisture content was the only property measured at the 18-in. depth in the subgrade; plots for the three fields are shown in plates 14, 17, and 20, and are summarized below:

<u>Field</u>	<u>Rainfall Zone</u>	<u>Classification of Subgrade at 18-in. Depth</u>			<u>Trend of Moisture with Time</u>
		<u>LL</u>	<u>PI</u>	<u>Symbol</u>	
Kirtland	-15	22	5	SM-SC	Not significant
Craig	+35	21	9	SC	Decreasing
Sewart	+35	57	38	CH	Not significant

No general trends of changes in moisture content at the 18-in. depth are shown by this tabulation.

Variations in Soil Properties Across Pavement Width

31. Profiles of moisture content, density, CBR, percentage of saturation, and gradients for each testing are presented in plates 21-24. The gradients are analyzed by comparing conditions in the more heavily traveled interior portions of the pavement with conditions at the relatively untraveled edges of the pavement. Comparisons are made according to the slopes of the gradients, which are considered as showing an increase or decrease when an average line drawn through the points has a general upward or downward slope.

Moisture content

32. Plots showing the moisture content gradient for each testing at each field are shown in plate 21. The plots show the moisture contents determined on the base course and at two elevations in the subgrade for the normal and shoulder locations.

33. No trend is apparent for the behavior of moisture in the base courses of the three fields investigated. The variations in moisture content from the center of the pavement to the shoulder are not significant in the base courses. For the two elevations of subgrade investigated, moisture content changes are inconsistent: Kirtland AFB shows a decrease from

the center of the pavement outward, Craig AFB shows an increase, and Sewart AFB is inconsistent.

#### Density

34. Density gradients for base and subgrade surface locations are shown in plate 22. Density is not considered as changing with time. However, analysis of the base course data in plate 22 shows that the density profile from the center of the pavement to the shoulder remains constant or increases. In general, the subgrade profile tends to remain constant or show a decrease in density at the shoulder.

#### CBR

35. A plot of the CBR gradients at each test location of the base course and subgrade surface is shown in plate 23. There appears to be a general trend for a decrease in CBR to occur from the center of the pavement toward the edge in both the base and subgrade materials, with the exception of the subgrade at Sewart AFB which shows a marked increase in CBR at the shoulder location.

#### Degree of saturation

36. A plot of the degree of saturation at each test location for the base course and subgrade surface is shown in plate 24. There appears to be no general trend for change in the degree of saturation from the center of the pavement to the edge in either the base course or the subgrade, with the exception of the subgrade surface at Kirtland AFB which shows a marked decrease in degree of saturation at the shoulder location.

#### Other Relations

37. An analysis of the studies of the relations between moisture content, density, degree of saturation, and other variables is given in the following paragraphs. A single value has been selected to represent all values obtained during the investigation at each field or at a certain location at a given field. These values are either average values obtained from numerical averaging or mode values representing a particular percentage of observations obtained from frequency distribution curves.

38. Data obtained during the 1945-1952 investigation are presented here to establish certain trends, and data obtained during this phase

(1952-1956) of the investigation are used either to substantiate these trends or to give added weight to the indications that no trends exist.

Moisture content versus Atterberg limits

39. Liquid limit. Plots of in-place moisture content versus liquid limit for the base course and subgrade surface are shown in plate 25 and for the 18-in. depth in the subgrade in plate 26. Symbols are used to designate the various rainfall zones. The points represent average moisture content values determined at normal locations each time a field was tested. General increases in moisture content occur with increases in liquid limit in the base course and in both subgrade elevations. No trend in moisture content with rainfall zone is indicated for the base course. Although some data plotted inconsistently, the following general trends are indicated.

- a. Moisture contents at the surface of the subgrade in the low rainfall areas plot lower than those of the other two areas.
- b. At the 18-in. depth, values for the low rainfall zone plot below those for the high rainfall zones.
- c. The moisture content was below the liquid limit in both the base and subgrade in all cases.

40. Plastic limit. Plots of in-place moisture content versus plastic limit are shown in plate 27 for the base course and subgrade surface and in plate 28 for the 18-in. depth in the subgrade. The general trends indicated are as follows:

- a. Moisture contents at the subgrade surface and 18-in. depth are lower in the low rainfall zone than in the medium or high rainfall zones.
- b. Moisture contents show a general increase with increase in plastic limit.
- c. Moisture contents in the base course did not exceed the plastic limit, but subgrade moisture contents at both elevations were found to exceed plastic limits in all rainfall zones.
- d. Moisture content and plastic limit show no relation to rainfall zone.

41. Plasticity index. Plots showing the relation of moisture content to plasticity index are shown in plate 29 for the base course, plate 30 for the surface of the subgrade, and plate 31 for the 18-in. depth in

the subgrade. The following general trends are indicated:

- a. Moisture content increases with an increase in plasticity.
- b. Points plotted for the high rainfall zone are higher than those for the other zones at the 18-in. depth in the subgrade. At other elevations there does not appear to be a relation between moisture content and rainfall zone.

In-place versus optimum moisture content

42. Plots of in-place moisture content versus optimum moisture content for the base course, subgrade surface, and 18-in. depth in the subgrade are shown in plates 32 and 33. In general, base course optimum moisture contents tend to be higher than the in-place values, and also there is a trend for the in-place moisture content to be higher with increasing optimum moisture content. For both elevations in the subgrade, it can be noted that the trend is for the in-place moisture content to be higher than the optimum moisture content. It is also apparent that in-place values vary directly with optimum moisture content values at both elevations in the subgrade.

Moisture content versus gradation of material

43. Plots of moisture contents of base course, subgrade surface, and 18-in. depth in the subgrade versus the percentage of material passing the No. 200 sieve are shown in plates 34 and 35. The values shown in plate 35 are only for the fields studied during the 1952-1956 phase of the investigation. The general trend indicates that moisture content varies directly with the amount of material passing the No. 200 sieve.

Moisture content and rainfall versus time

44. A study of the data available reveals no relation between moisture content and rainfall with time.

Moisture content:liquid limit ratio versus gradation and rainfall

45. Gradation. The in-place moisture content:liquid limit ratios for the base course and subgrade surface are shown in plate 36. The ratio is not above 1.00 for either base or subgrade. For the base course materials, there is a trend for the ratio to increase as the amount of material

passing the No. 200 sieve increases. No trend was indicated for the subgrade materials.

46. Annual rainfall. Plate 37 shows plots of the base course and subgrade surface in-place moisture content:liquid limit ratios versus the average annual rainfall. No relation between this ratio and the annual rainfall is apparent.

Moisture content:plastic limit ratio  
versus gradation and annual rainfall

47. Gradation. Plots of the in-place moisture content:plastic limit ratio versus percentage of material passing the No. 200 sieve for both base course and subgrade surface materials are shown in plate 38. A trend for the ratio to increase as the amount of material passing the No. 200 sieve increases is apparent for both base and subgrade. This ratio does not exceed 1.00 for base course materials, but does exceed 1.00 a significant number of times when the amount of subgrade material passing the No. 200 sieve is more than 35 per cent.

48. Annual rainfall. Plots of the in-place moisture content:plastic limit ratios of the base course and subgrade surface materials versus average annual rainfall are shown in plate 39. These data indicate no definite relation between this ratio and average annual rainfall. Similar data presented in Report 2 for the 18-in. depth of subgrade showed a trend for the ratio to vary directly with the rainfall.

Moisture content:optimum moisture content ratio versus rainfall

49. Mode values of the ratio of the in-place moisture content to the modified AASHO optimum moisture content for base course and surface of the subgrade are shown plotted against the average annual rainfall in plate 40. These plots show no relation between the value of the ratio and the average annual rainfall.

Water:plasticity ratio

50. The water:plasticity ratio was defined in Report 2 as 
$$\frac{\text{moisture content minus plastic limit}}{\text{liquid limit minus plastic limit}}$$
. The water:plasticity ratio is

plotted against average in-place moisture content values for base course, subgrade surface, and 18-in. depth in the subgrade in plate 41. Moisture

content values shown are arithmetic averages for the period of investigation, and locations have been combined where limits are approximately the same. Data from this phase of the investigation do not tend to alter the following summary of the Report 2 analysis of this variable.

- a. Base course. Points representing base courses show water:plasticity ratio values ranging roughly from 0 to -12. In no case does the average in-place moisture content exceed the plastic limit, hence the negative values on the abscissa. There is a general tendency for the moisture content to increase as the water:plasticity ratio increases. No relation between water:plasticity ratio and average annual rainfall could be ascertained.
- b. Subgrade surface. In general the values of water:plasticity ratio are between 0 and -1, indicating that average in-place moisture contents are just below the plastic limits of all materials with plasticity. The in-place moisture content varies directly with the water:plasticity ratio. No relation was found between water:plasticity ratio and average annual rainfall. It is to be noted that there were no failures in the subgrade.
- c. Subgrade, 18-in. depth. Water:plasticity ratios vary slightly  $\pm 0$ , indicating the average moisture contents to be very near the plastic limit. In-place moisture content values vary directly with water:plasticity ratio. Investigation of the relation between water:plasticity ratio and average annual rainfall indicated a slight trend for the ratio to increase with increasing rainfall.

#### Degree of saturation versus other variables

51. Plasticity index. Plots of the degree of saturation of the base course and subgrade surface versus plasticity index are shown in plate 42. In general, there appears to be a trend for the degree of saturation to vary directly with the plasticity index for the subgrade surface, and a slightly similar trend is noted for the base.

52. Gradation of material. The degree of saturation was found to have no relation to the amount of base course material passing the No. 200 sieve and only a slight direct relation to the amount of subgrade material passing the No. 200 sieve.

53. Annual rainfall. General indications are that there is no trend for the degree of saturation to vary with average annual rainfall.

#### CBR

54. In laboratory CBR tests made for design purposes, remolded,

soaked samples are used, it being assumed that the soaked samples will attain about the same degree of saturation and CBR as will base and subgrade materials in their worst future condition. In-place construction data for the fields investigated have been presented previously, and laboratory CBR tests were performed on samples from the sites tested during the period of this study and those tested during the phase of the investigation described in Report 2. Future conditions were predicted from laboratory tests on soaked samples that had been compacted at the actual construction moisture contents and densities rather than on samples compacted at the optimum moisture and the design density so that a direct comparison could be made between laboratory predictions and the actual in-place values found. This comparison is presented graphically in plate 43 for the base courses and subgrades of a majority of the fields tested during the 1945-1952 and 1952-1956 phases of the field moisture content investigation. The data presented in plate 43 are so arranged that values on the ordinates of the graphs above the laboratory value, shown as a bar, are on the unsafe side of the laboratory figure while those below the laboratory value are on the safe side. Laboratory-predicted moisture contents of base courses were found to be conservative in five cases and marginal in a single case (Clovis AFB). The laboratory-predicted moisture content values for the subgrades were found to be conservative in five cases and marginal in four. In-place base course CBR values plot well below (on the safe side of) the laboratory-predicted value for Kirtland AFB site 1, Bergstrom AFB, and Goodfellow AFB. All in-place base course CBR values at Kirtland AFB site 2 are less than the laboratory-predicted value; CBR's measured at Clovis AFB plot at or below the laboratory value before failure of the base, but well above after failure. In-place base course CBR values obtained at Craig AFB are both above and below the laboratory-predicted value, with approximately 70 per cent being on the safe side. Laboratory-predicted CBR values for the subgrade were found to be conservative in seven cases and only slightly marginal in two cases.

## PART V: SUMMARY OF RESULTS, AND CONCLUSIONS

Results

55. The following statements are based on the data obtained in this and the previous investigation, and the foregoing analysis. Although the statements apply mainly to the sites investigated, they may also apply to other locations that exhibit similar climate, landforms, and soils.

- a. Variations in moisture content with time (all elevations) followed no prescribed pattern of increase or decrease.
- b. The 18-in. depth in the subgrade was the only elevation to exhibit a trend of higher moisture content in the high rainfall zone.
- c. In-place moisture contents varied directly with liquid limit, plastic limit, plasticity index, optimum moisture content, and percentage of material passing a No. 200 sieve.
- d. Moisture contents were below the plastic limits in the base courses, but not in all of the subgrade materials.
- e. There was no trend for the degree of saturation to vary with the rainfall zone.
- f. The variation of moisture content across the pavement width (normal locations 1, 2, and 3) was insignificant in the base courses and inconsistent for the two elevations in the subgrade. There was no trend for the moisture content to vary from the center of the pavement outward with rainfall zone.
- g. The moisture contents and CBR values of laboratory soaked samples were generally conservative compared to those obtained in the field for base courses, and conservative or approximate to those obtained for subgrade materials.

Conclusions

56. From the foregoing it is concluded that the moisture contents beneath pavements, as well as the physical properties of the soils, vary according to material and location (field). This variation cannot be definitely related to rainfall zone or climatic region; neither was the source of moisture definitely determined. Good surface drainage is a contributing factor to satisfactory pavement performance but will not necessarily ensure it. The four-day laboratory soaking test, although possibly conservative for nonplastic or slightly plastic materials (particularly in arid regions), is still considered applicable for purposes of design.

Table 1  
Summary of Test Data  
Kirtland Air Force Base, Site 2, Taxiway 8

Location No.	Course	Depth from Surface in.	Soil Characteristics				In-Place Test Data																
							20 February 1953			4 June 1953			16 September 1953			14 January 1954							
			LI *	PI *	F <sub>1</sub> %	Class- ification	CBR	Density lb/cu ft	Moisture Content % Dry Wt	CBR	Density lb/cu ft	Moisture Content % Dry Wt	CBR	Density lb/cu ft	Moisture Content % Dry Wt	CBR	Density lb/cu ft	Moisture Content % Dry Wt					
1 4 ft	Base	4	NP	2.70	GW	81	140.9	3.0	42	112	147.2	1.8	34	130	142.3	2.1	31	113	140.0	3.7	36		
	Subgrade	11	22	17	5	2.69	SM-SC	37	116.7**	8.1	53	66	114.6	8.1	48	72	112.1	6.5	36	64	114.3	7.3	43
	Subgrade	30	22	17	5	2.65	SM-SC					8.9					7.9					8.4	
2 21 ft south of 1	Base	4	NP	2.70	GW	77	142.7	2.4	37	90	146.9	1.6	31	133	145.5	1.5	27	106	141.3	2.1	30		
	Subgrade	11	21	18	4	2.64	SM-SC	56	125.5**	8.6	71	68	116.4	8.9	55	97	119.3	6.9	47	97	116.9	6.4	40
	Subgrade	30	22	17	5	2.65	SM-SC					7.4					6.3					6.5	
3 40.5 ft south of 2	Base	4	NP	2.70	GW	89	141.9	2.3	34	97	146.7	1.9	35	127	138.4	1.7	21	91	141.6	2.3	34		
	Subgrade	11	21	17	4	2.65	SM-SC	66	126.1**	8.3	70	86	116.1	7.8	48	79	114.2	6.6	38	95	116.5	5.8	34
	Subgrade	30	21	17	4	2.65	SM-SC					5.9					6.9					6.4	
4 (shoulder) 115.5 ft south of 3	Base	4			SM	15	95.1**	3.6	13	11	90.2	7.0	13	15	93.6	2.5	14	9	92.8	5.7	13		
	Subgrade	12	20	15	5	2.62	SM-SC					3.9					3.9					3.8	
	Subgrade	30	19	16	3	2.65	SM					3.2					3.8					5.0	
1 4 ft	Base	4	NP	2.70	GW	128	142.5	1.8	27	154+	143.8	1.9	31	136	143.3	2.0	31						
	Subgrade	11	22	17	5	2.69	SM-SC	56	113.8	6.6	38	67	115.1	6.3	38	100	115.6	7.6	46				
	Subgrade	30	22	17	5	2.65	SM-SC					7.9					8.6						
2 21 ft south of 1	Base	4	NP	2.70	GW	108	143.1	1.4	22	121+	145.0	0.9	15	148+	141.9	1.8	26						
	Subgrade	11	21	18	4	2.64	SM-SC	95	111.8	7.5	41	107	115.7	6.4	38	109	116.4	7.3	45				
	Subgrade	30	22	17	5	2.65	SM-SC					6.5					7.7						
3 40.5 ft south of 2	Base	4	NP	2.70	GW	127+	142.5	1.4	21	128	146.2	0.9	17	103	144.5	2.2	37						
	Subgrade	11	21	17	4	2.65	SM-SC	90	110.4	6.4	33	116	119.0	5.8	39	86	110.8	7.9	42				
	Subgrade	30	21	17	4	2.65	SM-SC					6.0					6.6						
4 (shoulder) 115.5 ft south of 3	Base	4			SM			5.8	15			3.8					4.7						
	Subgrade	12	20	15	5	2.62	SM-SC	10	89.2	4.8		12	91.9	3.0	10	13	91.6	4.1	14				
	Subgrade	30	19	16	3	2.65	SM					3.9					3.8						

\* Average of values shown in table 4, Summary of Laboratory Test Data.  
\*\* Density obtained by sand-displacement method.

Table 2

Summary of Test Data  
Craig Air Force Base, Site 2, m-SM Runway Extension

Location No.	Course	Depth from Surface ft.	Soil Characteristics				26 August 1952*				9 November 1952*				16 March 1953				27 August 1953			
			No.	Fl	#	Soil Classification	Moisture Content % Dry wt	Density lb/cu ft	CGR	Set.	Moisture Content % Dry wt	Density lb/cu ft	CGR	Set.	Moisture Content % Dry wt	Density lb/cu ft	CGR	Set.	Moisture Content % Dry wt	Density lb/cu ft	CGR	Set.
1	Base Subgrade	2	30	14	16	2.66	6.0	131.3	72	131.3	5.9	70	133.6	6.6	72	133.6	6.6	72	133.6	6.6	72	133.6
			23	13	10	2.66	10.0	111.3	19	111.3	9.4	27	116.9	9.7	27	116.9	9.7	27	116.9	9.7	27	116.9
			25	12	13	2.66	10.5				9.0			9.2								
2	Base Subgrade	2	31	15	16	2.67	6.1	134.7	61	134.7	6.4	80	135.5	6.1	67	134.4	6.3	72	134.4	6.3	72	134.4
			25	14	12	2.66	11.9	117.2	17	117.2	10.5	23	115.2	10.8	21	114.3	11.0	63	114.3	11.0	63	114.3
			17	11	6	2.66	13.5				9.5			10.5								
3††	Base Subgrade	2	31	15	16	2.67	6.5	131.4	49	131.4	5.7	59	134.1	6.3	72	131.9	6.4	66	133.8	6.4	66	133.8
			24	13	11	2.66	9.8	122.1	26	122.1	9.4	47	121.8	10.0	74	119.9	10.6	64	118.4	10.6	64	118.4
			20	11	9	2.66	11.7				11.7			10.9								
4	Base Subgrade	4	31	17	14	2.67	3.8	107.4	7	107.4	3.6	14	120.2	13.0	83	114.9	13.0	73	114.9	13.0	73	114.9
			25	18	8	2.66	13.9				11.2			12.6								
			11	16	17	2.66	16.1				14.4			17.6								
1	Base Subgrade	2	30	14	16	2.66	7.0	137.2	73	137.2	6.6	73	134.4	6.5	68	134.6	6.9	79	134.6	6.9	79	134.6
			23	13	10	2.66	9.5	118.9	29	118.9	9.5	26	118.0	9.4	52	117.5	8.7	54	117.5	8.7	54	117.5
			27	12	13	2.66	9.9				9.5			9.5								
2	Base Subgrade	2	31	15	16	2.67	6.5	135.5	54	135.5	6.3	63	131.6	6.1	69	137.5	6.6	85	135.4	6.6	85	135.4
			25	14	12	2.66	11.1	119.3	27	119.3	10.7	28	118.2	10.5	53	119.6	10.8	71	118.7	10.8	71	118.7
			17	11	6	2.66	9.9				10.5			9.5								
3††	Base Subgrade	2	31	15	16	2.67	7.1	131.9	41	131.9	6.8	55	136.2	6.3	68	133.9	6.7	75	133.9	6.7	75	133.9
			24	13	11	2.66	9.8	118.5	29	118.5	10.4	29	122.4	8.7	60	122.1	9.1	65	122.1	9.1	65	122.1
			20	11	9	2.66	11.1				11.0			10.1								
4	Base Subgrade	4	31	17	14	2.67	12.1	109.2	5	109.2	7.9	14	115.2	5.1	28	112.1	7.6	39	112.1	7.6	39	112.1
			25	18	8	2.66	11.7				11.9			14.6								
			33	16	7	2.66	16.6				16.9			5.2								

\* Average of values shown in Table 1, Summary of Laboratory Test Data.  
 † No pavement in place on 26 August 1952, but depths shown represent after-paving conditions.  
 †† Runway paved prior to this testing.  
 †† This data was reproduced after these tests and before placing of pavement.



Table 4  
Summary of Laboratory Test Data

Field	Facility	Location No.	Hole No.	Date Sampled	Material	Depth in.	Description	Characteristics				Mechanical Analysis				Modified AASHTO		
								Classification	LL	PL	PI	% Gravel	% Sand	% Passing No. 200	Specific Gravity	Maximum Density lb/cu ft	Optimum Moisture Content %	
Kirtland AFB	Taxiway 8	1	Test pit 1-A 1-C	6-3-53	Base	7	Gravel-sand	GW	23	18	5	52	45	3	2.70	142.7	5.8	
				5-7-54	Base	7	Gravel-sand	GW	22	15	7	0	55	45	2.69	129.0	9.5	
				1-14-55	Base	7	Gravel-sand	GW	21	18	3	0	57	43	2.69	129.0	9.5	
				Average														
			Test pit 1-A 1-B 1-C	6-3-53	Subgrade	11	Clayey sand (caliche)	SM-SC	23	18	5	0	55	45	2.69	129.0	9.5	
				7-7-53	Subgrade	15	Clayey sand (caliche)	SM-SC	22	15	7	4	67	29	2.69	129.0	9.5	
				5-7-54	Subgrade	11	Silty sand	SM	21	18	3	0	57	43	2.69	129.0	9.5	
				7-27-54	Subgrade	11	Silty sand	SM	23	19	4	0	57	43	2.69	129.0	9.5	
			1-14-55	Subgrade	11	Silty sand	SM	22	17	5	2	59	39	2.69	129.0	9.5		
				Average														
				7-27-54	Subgrade	28	Silty sand (caliche)	SM-SC	21	16	5	0	56	44	2.65	129.0	9.5	
				1-14-55	Subgrade	28	Silty sand (caliche)	SM-SC	23	19	4	0	56	44	2.65	129.0	9.5	
			2	2-A 2-C	5-7-54	Base	5	Gravel-sand	GW	22	17	5	2	59	39	2.69	129.0	9.5
					1-14-55	Base	5	Gravel-sand	GW	22	17	5	2	59	39	2.69	129.0	9.5
Average																		
7-7-53	Subgrade	15			Silty sand	SM-SC	22	17	5	0	55	45	2.64					
		Test pit* 2-A 2-B 2-C	5-7-54	Subgrade	13	Silty sand	SM	21	18	3	0	55	45	2.64				
			7-27-54	Subgrade	11	Silty sand	SM	20	17	3	0	55	45	2.64				
			1-14-55	Subgrade	11	Silty sand	SM	21	18	3	0	55	45	2.64				
			Average															
		2-A 2-B 2-C	5-7-54	Subgrade	28	Silty sand	SM-SC	22	17	5	0	55	45	2.64				
			7-27-54	Subgrade	28	Clayey sand	SC	23	15	8	0	55	45	2.64				
			1-14-55	Subgrade	28	Silty sand	SM	21	18	3	0	55	45	2.64				
			Average															
		3	3-A 3-C	5-7-54	Base	5	Gravel-sand	GW	22	17	5	0	55	45	2.65			
				1-14-55	Base	5	Gravel-sand	GW	22	17	5	0	55	45	2.65			
				Average														
				7-7-53	Subgrade	13	Silty sand	SM	21	17	4	0	55	45	2.65			
		Test pit* 3-A 3-B 3-C	5-7-54	Subgrade	11	Silty sand	SM-SC	21	17	4	0	55	45	2.65				
			7-27-54	Subgrade	11	Silty sand	SM-SC	21	17	4	0	55	45	2.65				
1-14-55	Subgrade		11	Silty sand	SM	21	17	4	0	55	45	2.65						
Average																		
3-A 3-B	5-7-54 7-27-54	Subgrade	11	Silty sand	SM-SC	21	17	4	0	55	45	2.65						
		Subgrade	28	Silty sand	SM-SC	22	18	4	0	55	45	2.65						
		Subgrade	28	Silty sand	SM-SC	20	16	4	0	55	45	2.65						
		Average																

\* Tests performed on materials from previous test sites at these fields, but observed to be similar to that at new test location.

Table 4 (Continued)

Field	Facility	Location No.	Hole No.	Date Sampled	Material	Depth ft.	Description	Characteristics				Mechanical Analysis		Specific Gravity	Maximum Moisture Content	
								Class- sification	LL	PL	PI	% Gravel	% Sand		lb/cu ft	%
Kirtland AFB (Cont'd)	Taxiway 8 (Cont'd)	4	Test pit	7-7-53	Subgrade	13	Silty sand (caliche)	SM-SC	18	14	4			2.62		
			4-A	5-7-54	Subgrade	10	Silty sand (caliche)	SM-SC	23	17	6					
			4-B	7-27-54	Subgrade	10	Silty sand (caliche)	SM-SC	19	15	4	0	63	37		
			4-C	1-14-55	Subgrade	10	Silty sand	SM								
			Average			11			20	15	5					
			4-A	5-7-54	Subgrade	28	Silty sand (caliche)	SM-SC	21	16	5					
			4-B	7-27-54	Subgrade	28	Silty sand	SM	17	16	1	0	67	33	2.65	
			Average			28			19	16	3					
			Test pit	8-15-51	Base	2	Clayey gravelly sand	SC	27	13	14	24	59	17	134.5	7.0
			1-A-1-B	11-7-52	Base	2	Clayey gravelly sand	SC	33	14	19	24	55	21	2.67	2.65
Crown AFB	RW-55 runway (14-32)	1	1-A	10-20-53	Base	2	Clayey gravelly sand	SC	29	14	15					
			1-B	4-22-54	Base	3	Clayey gravelly sand	SC	29	14	15					
			1-C	5-17-54	Base	2	Clayey gravelly sand	SC	28	15	13					
			1-D	9-8-54	Base	2	Clayey gravelly sand	SC	32	17	15					
			1-A	12-15-54	Base	2	Clayey gravelly sand	SC	30	14	16					
			Average			2			30	14	16					
			Test pit	11-7-52	Subgrade	11	Clayey sand	SC	30	12	18	3	60	37	2.66	2.68
			1-A	10-20-53	Subgrade	10-1/4	Clayey sand	SC	23	11	12					
			1-B	4-22-54	Subgrade	10-1/2	Clayey sand	SC	20	11	9					
			1-C	5-17-54	Subgrade	10-1/2	Clayey sand	SC	25	12	13					
			1-D	9-8-54	Subgrade	10-1/2	Clayey sand	SC	24	12	12					
			1-A	1-5-54	Subgrade	10-1/2	Clayey sand	SC	17	13	4					
			1-A	8-27-55	Subgrade	10-1/2	Clayey sand	SC	20	17	3					
			Average			11			23	13	10					
			Test pit	11-7-52	Subgrade	30	Clayey sand	SC	31	13	18	17	39	44	2.66	
			1-D	9-8-54	Subgrade	28	Clayey sand	SC	19	11	8					
			1-A	12-15-54	Subgrade	30	Silty sand	SM								
			1-A	8-27-55	Subgrade	30	Silty sand	SM								
			Average			29			25	12	13					
			2-A	10-20-53	Base	3	Clayey gravelly sand	SC	34	14	20					
		2	2-B	4-22-54	Base	3	Clayey gravelly sand	SC	27	14	13					
			2-C	5-17-54	Base	2-1/2	Clayey gravelly sand	SC	26	13	13					
			2-D	9-8-54	Base	2-1/2	Clayey gravelly sand	SC	27	15	12					
			2-A	12-15-54	Base	2-1/2	Clayey gravelly sand	SC	38	15	23					
			Average			3			31	15	16					
			2-A	10-20-53	Subgrade	11-3/4	Clayey sand	SC	30	15	15					
			2-B	4-22-54	Subgrade	11-1/2	Clayey sand	SC	26	13	13					
			2-C	5-17-54	Subgrade	11-3/4	Silty sand	SM								
			2-D	9-8-54	Subgrade	11	Clayey sand	SC	26	14	12					
			2-A	12-15-54	Subgrade	11	Clayey sand	SC	22	14	8					
			2-A	8-27-55	Subgrade	11	Clayey sand	SC	27	14	13					
			Average			11			26	14	12					

(Continued)

\* Tests performed on materials from previous test sites at these fields, but observed to be similar to that at new test location.

Table 4 (Continued)

Field	Facility	Location No.	Hole No.	Date Sampled	Material	Depth in.	Description	Classification	Characteristics				Mechanical Analysis			Specific Gravity	Maximum Density lb/cu ft	Optimum Moisture Content %
									LL	PL	FI	PT	% Gravel	% Sand	% Passing No. 200			
Craig AFB (Cont'd)	HW-SW Runway (14-32) (Cont'd)	2	2-D	9-8-54	Subgrade	28	Clayey sand	SC	21	11	10							
				12-15-54	Subgrade	28	Silty sand	SM	15	12	3							
				8-27-55	Subgrade	30	Silty sand	SM	12	11	4							
				Average		28			17	11	6							
				11-7-52	Base	2	Clayey gravelly sand	SC	27	16	11							
		3	3-A-3-D	10-20-53	Base	3	Clayey gravelly sand	SC	34	15	19							
				4-22-54	Base	3	Clayey gravelly sand	SC	30	15	15							
				5-17-54	Base	2-1/4	Clayey gravelly sand	SC	32	15	17							
				9-8-54	Base	2-1/4	Clayey gravelly sand	SC	28	14	14							
				12-15-54	Base	2-1/4	Clayey gravelly sand	SC	36	15	21							
				Average		2-1/2			31	15	16							
				10-20-53	Subgrade	10-1/2	Clayey sand	SC	28	12	16							
				4-22-54	Subgrade	11	Clayey sand	SC	21	13	8							
				5-17-54	Subgrade	11-1/2	Clayey sand	SC	25	13	12							
				9-8-54	Subgrade	11-1/2	Clayey sand	SC	25	15	10							
				12-15-54	Subgrade	11-1/2	Clayey sand	SC	21	12	9							
				8-27-55	Subgrade	11-1/2	Silty sand	SM			NP							
				Average		11			24	13	11							
				9-8-54	Subgrade	28	Clayey sand	SC	20	11	9							
				12-15-54	Subgrade	28	Clayey sand	SC	19	11	8							
				Average		28			20	11	9							
Sewart AFB	HW-SW Runway (14-32)	4	4-D	9-8-54	Subgrade	4	Clayey sand	SC	31	17	14					2.66		
				Average		4			31	17	14							
				9-8-54	Subgrade	12	Clayey sand	SC	49	29	20							
				12-15-54	Subgrade	10	Silty sand	SM	13	12	1							
				8-27-55	Subgrade	10	Silty sand	SM	16	13	3							
				Average		11			26	18	8							
		1	T-P-3	7-3-53	Subgrade	30	Clayey sand	SC	31	13	18							
				9-8-54	Subgrade	30	Clayey sand	SC	42	23	19							
				12-15-54	Subgrade	28	Clayey sand	SC	28	15	13							
				8-27-55	Subgrade	30	Clayey sand	SC	30	13	17							
				Average		29			33	16	17							
				1-15-52	Base	4	Crushed limestone	GW			NP					2.73	130.8	3.0
				1-15-52	Base	12	Crushed limestone	GW			NP					2.72	130.3	2.2
				Average		8							74	24	2	2.73	130.7	2.8
				1-15-52	Subgrade	16	Red fat clay	CH	75	23	52					2.78	106.9	19.6
				1-20-54	Subgrade	16	Red fat clay	CH	84	33	51							
				5-17-54	Subgrade	15-1/2	Red fat clay	CH	53	21	32							
				8-8-54	Subgrade		Red fat clay	CH	63	24	39							
				12-19-54	Subgrade		Red fat clay	CH	61	21	40							
				8-24-55	Subgrade		Red fat clay	CH	68	22	46							
				Average		16			67	24	43							

(Continued)

062955E (3 of 4 sheets)

Table 4 (Concluded)

Field	Facility	Location No.	Hole No.	Date Sampled	Material	Depth in.	Description	Classification	Characteristics			Mechanical Analysis			Specific Gravity	Maximum Density lb/cu ft	Optimum Moisture Content %
									LL	PL	PI	% Gravel	% Sand	% Passing No. 200			
Sewer AFB (Cont'd)	NW-SE runway (14-32) (Cont'd)	1	T-P-3	1-15-52	Subgrade	28	Red fat clay	CH	68	22	46	0	6	94		101.6	19.6
			(Cont'd) T-P-3	1-15-52	Subgrade	40	Red fat clay	CH								101.0	24.0
			1-D	8-8-54	Subgrade	34	Red fat clay	CH	50	22	28						
			1-A	12-19-54	Subgrade	34	Red fat clay	CH	68	26	42						
		2	1-A	8-24-55	Subgrade	34	Red fat clay	CH	52	21	31						
					Average	34			61	23	39					101.3	21.8
			2-B	1-20-54	Subgrade	18-1/2	Red fat clay	CH	61	23	38						
			2-C	5-17-54	Subgrade	18-1/4	Red fat clay	CH	50	21	29						
			2-D	8-8-54	Subgrade	18-1/4	Red fat clay	CH	50	22	28						
			2-A	12-19-54	Subgrade	18-1/4	Red fat clay	CH	46	20	26						
			2-A	8-24-55	Subgrade	18-1/4	Red fat clay	CH	48	18	30						
		3			Average	18-1/4			51	21	30						
			2-D	8-8-54	Subgrade	34	Red fat clay	CH	42	19	23						
			2-A	12-19-54	Subgrade	34	Red fat clay	CH	67	28	39						
			2-A	8-24-55	Subgrade	34	Red fat clay	CH	72	22	43						
		4			Average	34			60	25	35						
			3-B	1-20-54	Subgrade	17	Red fat clay	CH	51	21	30						
			3-C	5-17-54	Subgrade	16	Red fat clay	CH	50	21	29						
			3-D	8-8-54	Subgrade	16	Red fat clay	CH	41	18	23						
		5	3-A	12-19-54	Subgrade	16	Red fat clay	CH	48	19	22						
			3-A	8-24-55	Subgrade	16	Red fat clay	CH	56	20	36						
					Average	16			49	20	29						
			3-D	8-8-54	Subgrade	34	Red fat clay	CH	48	22	26						
		6	3-A	12-19-54	Subgrade	34	Red fat clay	CH	68	28	40						
			3-A	8-24-55	Subgrade	34	Red fat clay	CH	84	28	56						
					Average	34			67	26	41						
			4-D	8-8-54	Subgrade	4	Silty clay	CL	31	17	14						
		7			Average	4			31	17	14						
			4-D	8-8-54	Subgrade	12	Silty clay	CL	49	29	20						
			4-A	12-19-54	Subgrade	10	Red fat clay	CH	72	28	44						
			4-A	8-24-55	Subgrade	10	Red fat clay	CH	60	22	38						
		8			Average	11			60	26	34						
			4-D	7-3-54	Subgrade	34	Red fat clay	CH	78	31	47						
			4-D	8-8-54	Subgrade	34	Silty clay	CL	42	23	19						
			4-A	12-19-54	Subgrade	34	Red fat clay	CH	68	28	40						
		9	4-A	8-24-55	Subgrade	20	Red fat clay	CH	78	29	49						
					Average	30			67	28	39						
		10															
		11															

Table 5

Summary of Test Results on Asphaltic Pavement Mixtures

LOCATION		DESCRIPTION			QUALITY				ASPHALT				AGGREGATE					REMARKS					
FACILITY	PATT NO.	TYPE AND CLASS	COURSE	THICKNESS INCHES	TYPE OF SAMPLE	UNIT WT LB PER CU FT	STAB- ILITY LB	FLOW 1/100 IN.	PER CENT VOIDS		PER CENT *	SP GR **	DUCT- ILITY CM	PENETRATION 1/100 CM	SP GR AND ABSORPTION †	GRADATION							
									TOTAL MIX	FILLED WITH ASPHALT						3/4	# 10		# 40	# 200			
Taxiway C	1	Asphaltic concrete, excellent	Surface	1-7/8	Cores	143.4	1003	15	5.7	69.7	5.8	1.016	8	33	2.05	1.41	2.08	0.81	100	47.3	29.7	3.8	Gravel aggregate
	2		Binder	1-9/16	Cores	144.4	806	13	6.1	64.1	4.8	1.018	18	40	2.84	1.88	0.97	100	39.7	26.8	4.7		
	3		Surface	2-1/8	Cores	145.2	1308	15	4.5	74.7	(5.8)	(1.016)											
			Binder	1-7/8	Cores	146.6	846	11	4.5	71.2	(4.8)	(1.018)											
			Surface	2-9/16	Recomp - 50 blows	143.7	2102	13	5.5	70.4	(5.8)	(1.016)											
			Binder	2-9/16	Recomp - 75 blows	145.7	2351	10	4.1	76.4	(5.8)	(1.016)											
			Surface	2-9/16	Recomp - 50 blows	146.5	1797	10	4.7	70.3	(4.8)	(1.018)											
			Binder	2-9/16	Recomp - 75 blows	148.1	2451	10	3.7	75.2	(4.8)	(1.018)											
			Surface	2-1/16	Cores	143.5	861	14	5.6	70.1	(5.8)	(1.016)											
			Binder	2-1/16	Cores	143.8	474	16	6.5	62.6	(4.8)	(1.018)											

\* Values shown in this column corrected for ash content. Values in parentheses assumed.

\*\* Not corrected for ash content.

† Apparent specific gravity and absorption, ASTM designations C127-42 and C128-42.

‡ Material broken down and recompactd twice.

\* Values shown in this column corrected for ash content. Values in parentheses assumed.  
 \*\* Not corrected for ash content.  
 † Apparent specific gravity and absorption, ASTM designations C127-42 and C128-42.  
 ‡ Material broken down and recompact twice.

Table 5 (Continued)

LOCATION		DESCRIPTION			QUALITY					ASPHALT			AGGREGATE					REMARKS			
FACILITY	PATT OR PIT NO.	TYPE AND CONDITION	COURSE	THICKNESS INCHES	TYPE OF SAMPLE	UNIT WT LB PER CU FT	STAB-ILITY LB	FLOW 1/100 IN.	PER CENT Voids		PER CENT *	SP GR **	DUCT-ILITY CM	SP GR		GRADATION					
									TOTAL MIX	FILLED WITH ASPHALT				+ # 10	- # 10	3/4	# 10		# 40	# 200	
W-10E runway extension	1 & 2	Asphaltic concrete, new	Surface	1-5/16	Core	140.8	400	14	6.5	68.6	6.1 (1.047)			(2.66)	(2.66)	100	51	33	7	Gravel aggregate	
					Core	145.1	577	12	3.6	80.3	(6.1) (1.047)			(2.66)	(2.66)						
					Recomp - 50 blows	140.3	751	14	7.9	60.7	5.3 (1.047)			2.66	2.66	100	56	38	6		
					Recomp - 75 blows	142.1	1044	10	6.8	64.6	(5.3) (1.047)			(2.66)	(2.66)						
W-10E runway extension	3	Asphaltic concrete, excellent	Surface	1-1/16	Core	140.0	369	25	11.0	49.5	4.9 (1.022)†			2.73	2.72	100	45.0	17.9	9.2	Granite aggregate	
					Recomp - 50 blows	150.8	2491	14	4.1	73.9	(4.9) (1.022)†										
					Recomp - 75 blows	152.0	2759	13	3.3	78.0	(4.9) (1.022)†										
					Core	145.3	646	34	8.5	53.0	4.2 (4.2)			2.72	2.72	98.7	27.3	11.2	6.4		
			Binder	1-5/16	Recomp - 50 blows	151.6	2152	17	4.5	69.0	4.2 (4.2)										
					Recomp - 75 blows	153.3	2559	15	3.4	74.8	(4.2) (4.2)										

\* Values shown in this column corrected for ash content. Values in parentheses assumed.

\*\* No ash correction.

† This value obtained during construction. It is used in all computations.

\* Values shown in this column corrected for ash content. Values in parentheses assumed.  
 \*\* No ash correction.  
 † This value obtained during construction. It is used in all computations.

Table 6

Rainfall Data

Field	Annual Rainfall, in.											Avg Annual Rainfall* in.	
	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955		1956
Kirtland AFB, Albuquerque, N. Mex., Weather Bureau, Airport	6.28	8.27	5.15	6.44	8.42	4.10	5.38	8.09	5.08	4.51	6.51		8.68
Craig AFB, Selma, Ala., Weather Bureau, Airport								21.95**	46.50	54.21	30.00	47.30	50.25
Sewart AFB, Smyrna, Tenn., Weather Bureau, Airport, Nashville, Tenn.								39.81	41.31	42.73	45.43	29.58†	45.03

\* Based on observations over periods of 28 to 35 years.

\*\* July through December.

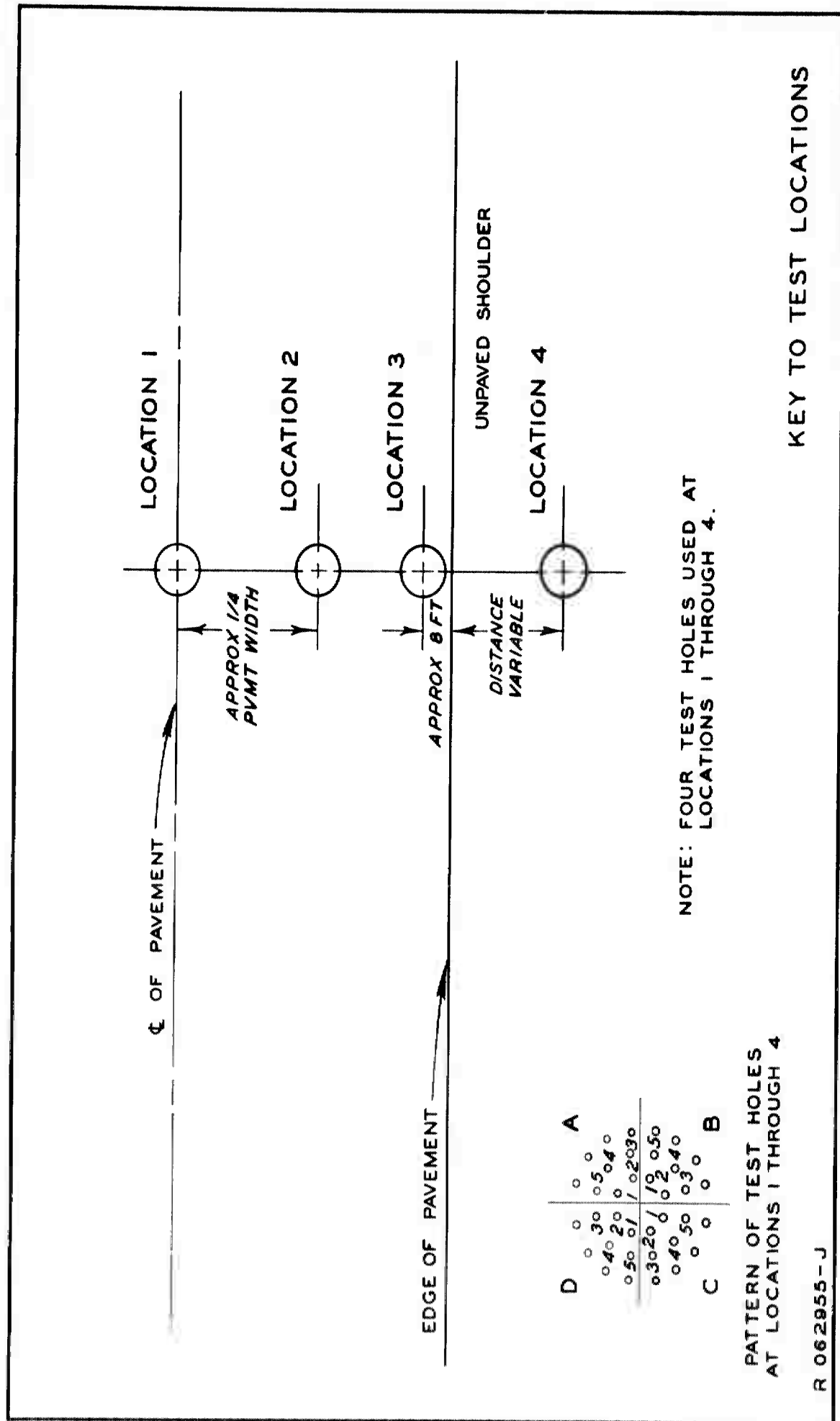
† Period January 1 to July 31.

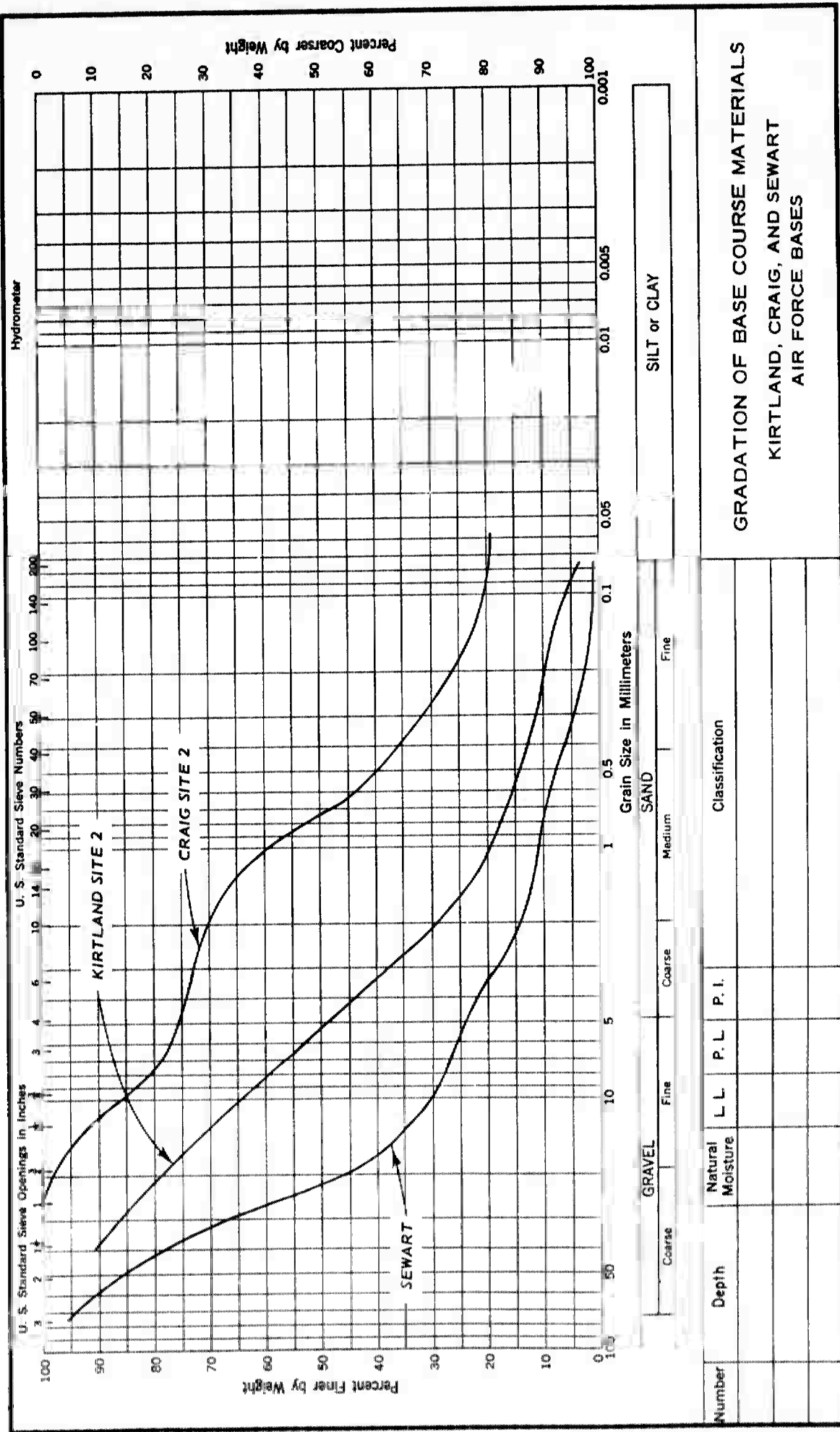
062955G

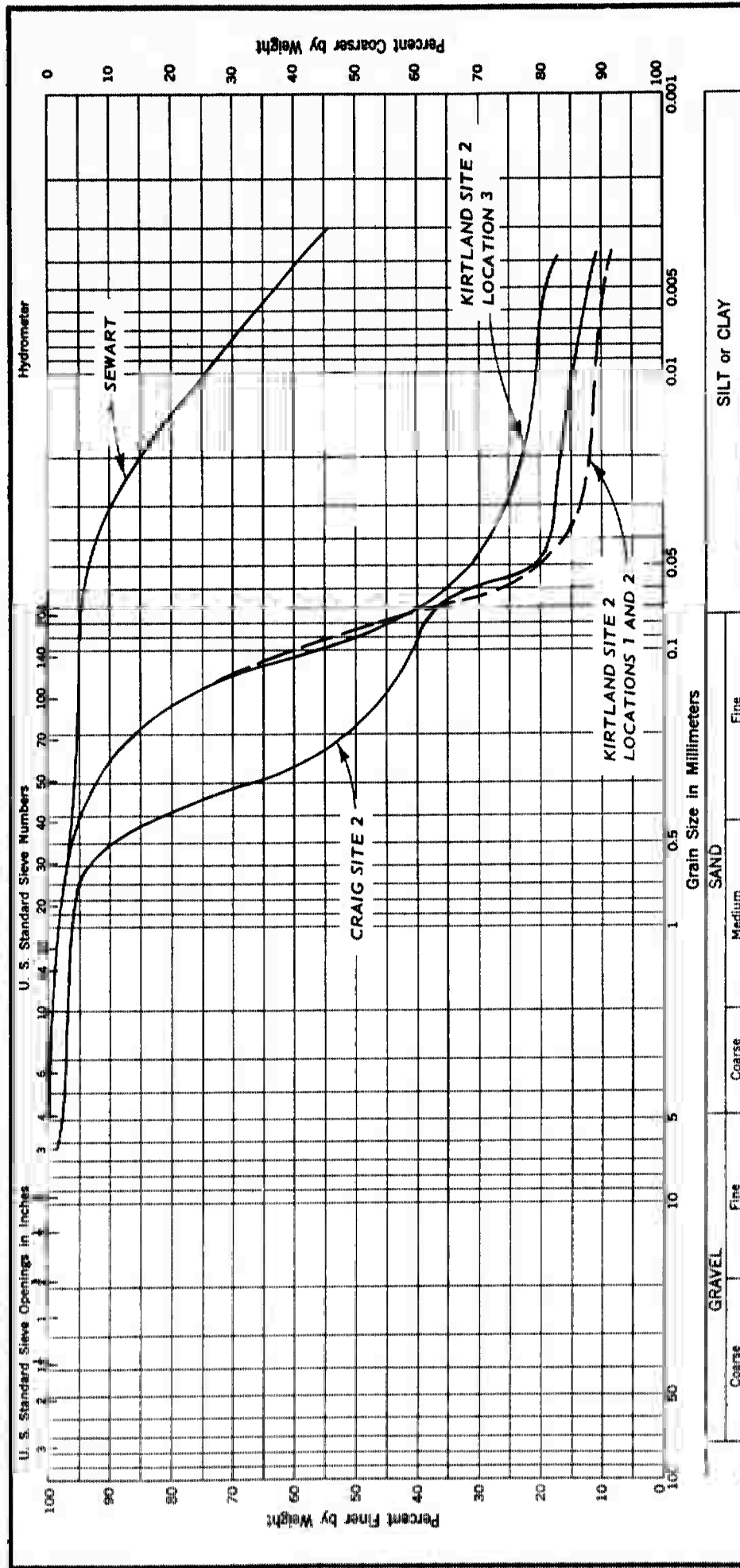
Table 7

Summary of In-place Construction Data

<u>Field</u>	<u>Course</u>	<u>Moisture Content, %</u>	<u>Density lb/cu ft</u>	<u>% Saturated</u>	<u>CBR</u>
Kirtland AFB, Site 2	Base	3.8	136.9	45	---
	Subgrade	9.2	123.5	72	---
Craig AFB, Site 2	Base	6.2	132.5	67	67
	Subgrade	10.6	116.9	68	21
Sewart AFB	Base	6.0	135.5	64	---
	Subgrade	24.2	98.1	88	5

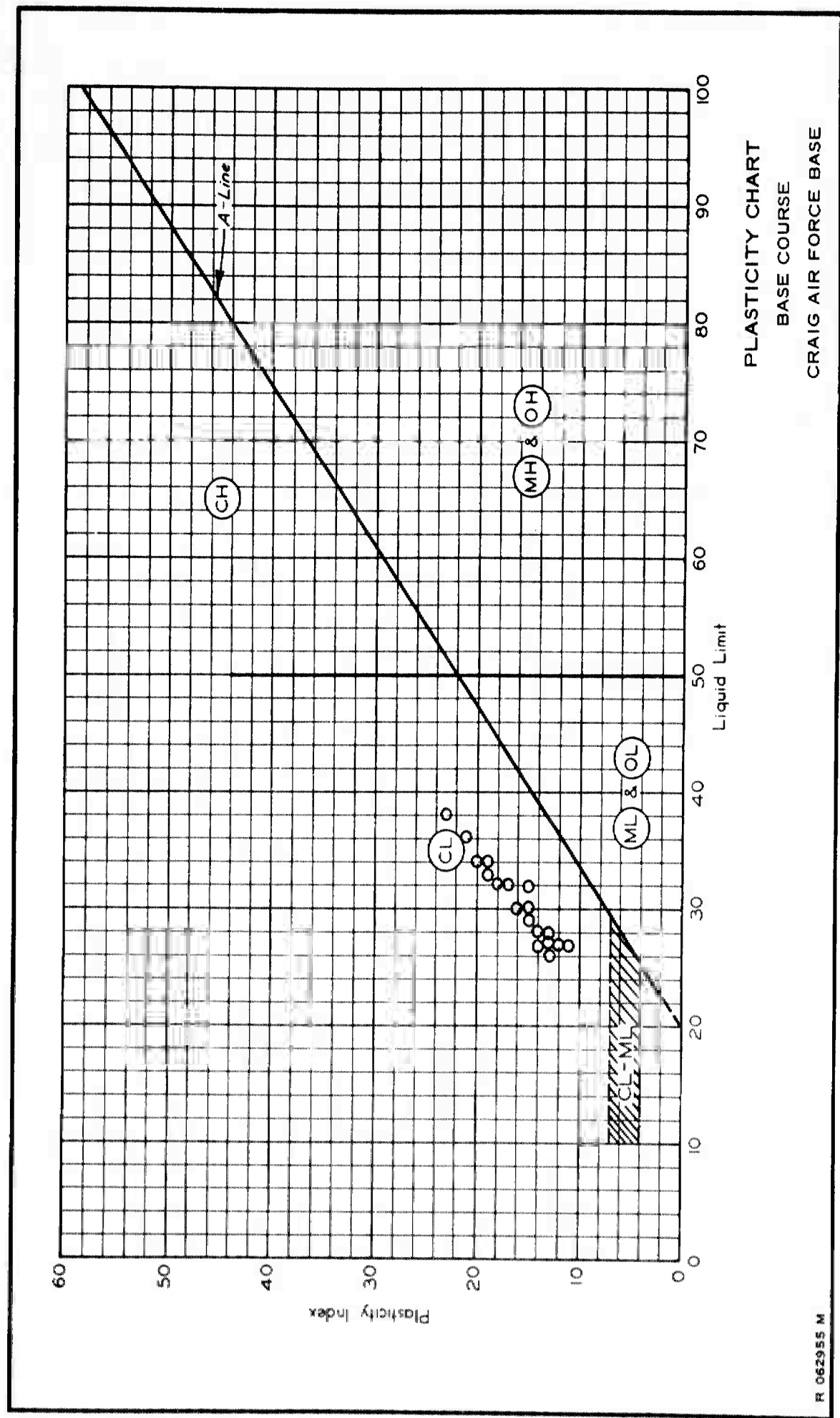


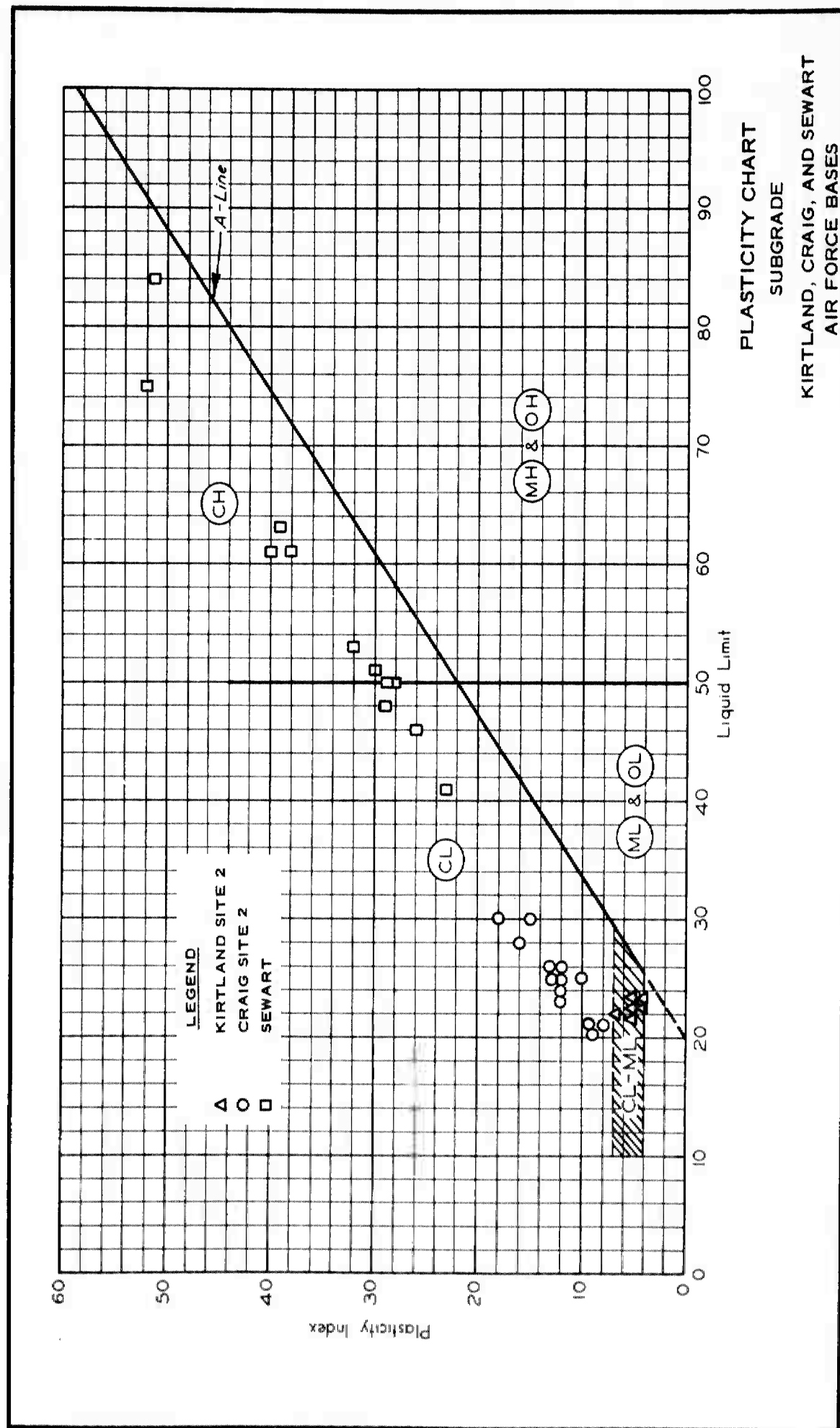


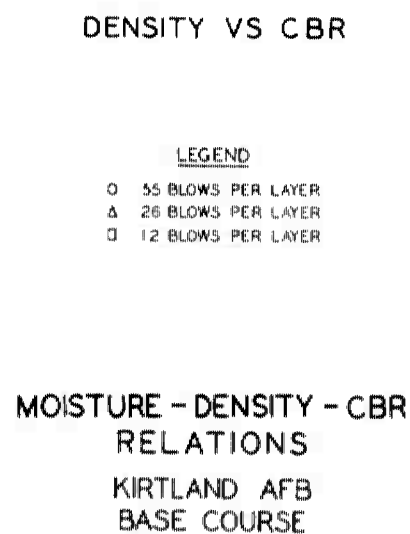
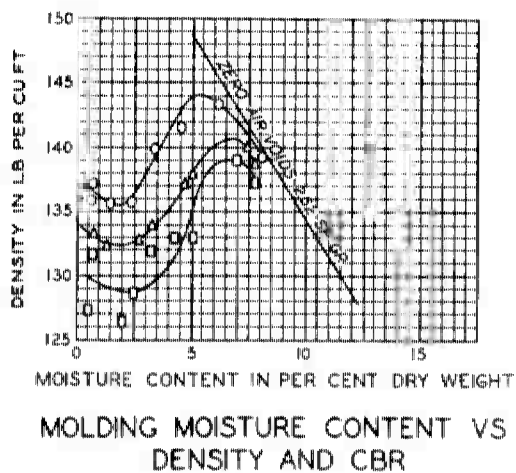
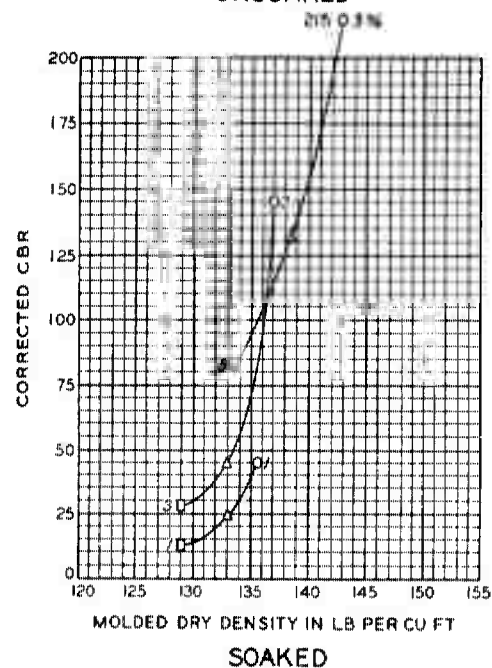
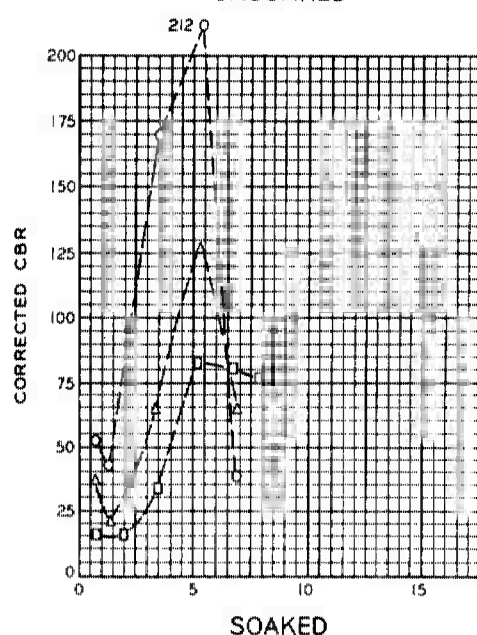
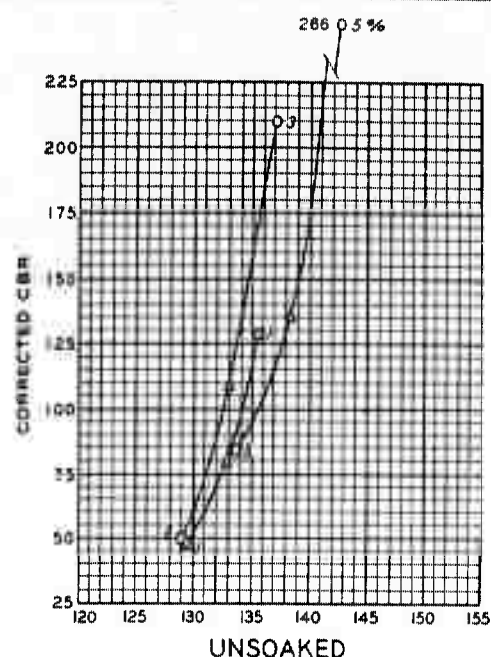
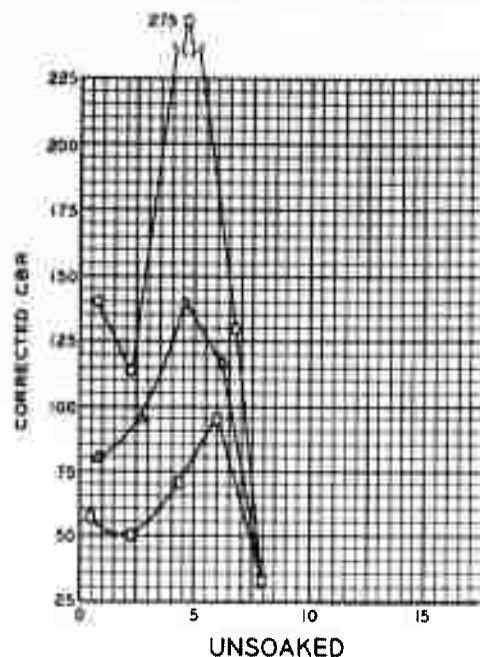


GRADATION OF SUBGRADE MATERIALS  
KIRTLAND, CRAIG, AND SEWART  
AIR FORCE BASES

Number	Depth	GRAVEL			SAND			SILT or CLAY		
		Coarse	Fine	Coarse	Medium	Fine	Coarse	Medium	Fine	Classification



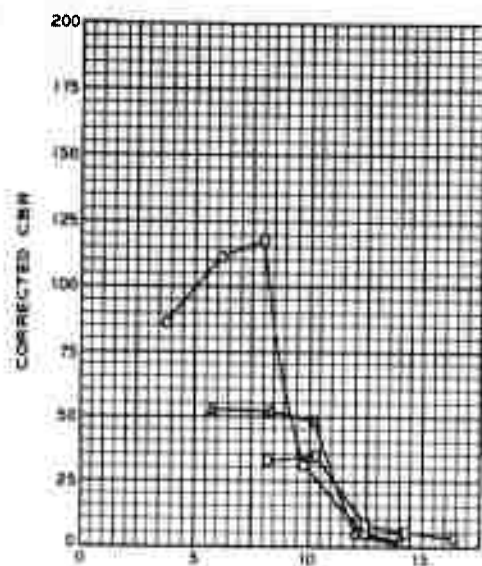




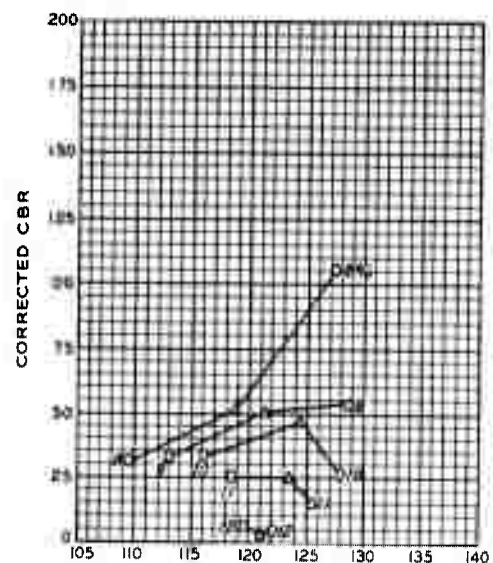
#### LEGEND

- O 55 BLOWS PER LAYER
- Δ 26 BLOWS PER LAYER
- 12 BLOWS PER LAYER

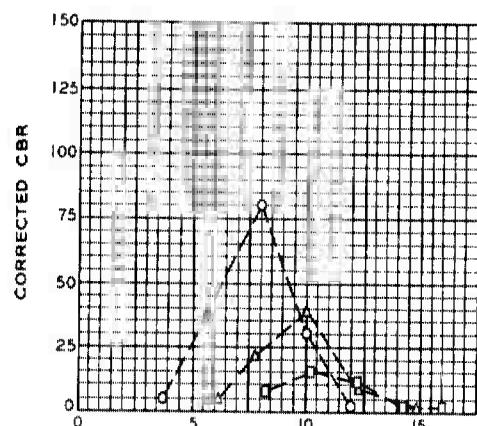
R 062955-P



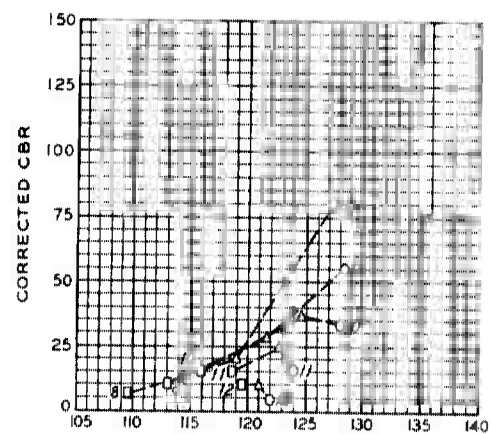
UNSOAKED



UNSOAKED

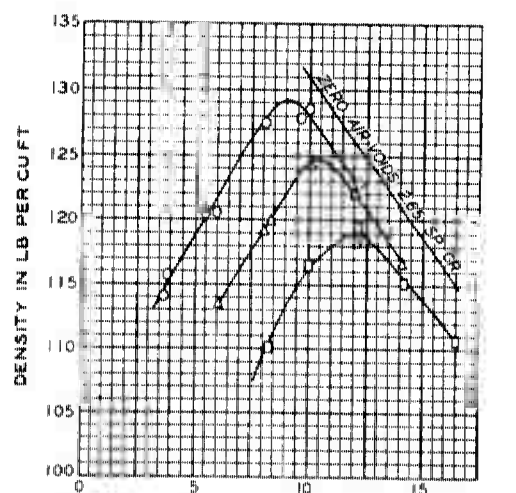


SOAKED



SOAKED

DENSITY VS CBR



MOISTURE CONTENT IN PER CENT DRY WEIGHT

MOLDING MOISTURE CONTENT VS  
DENSITY AND CBR

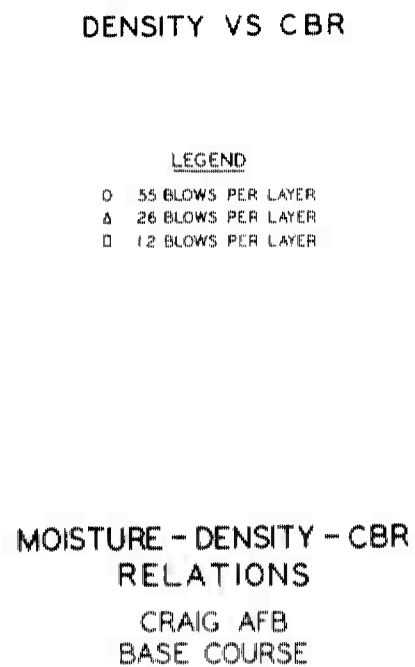
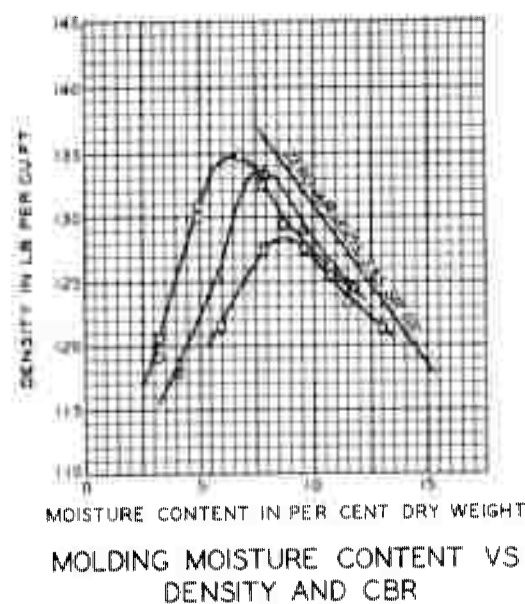
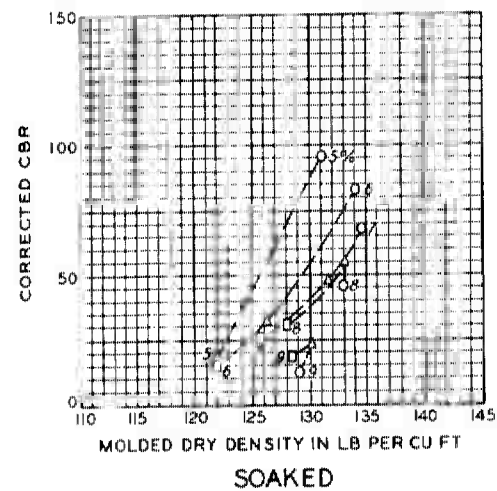
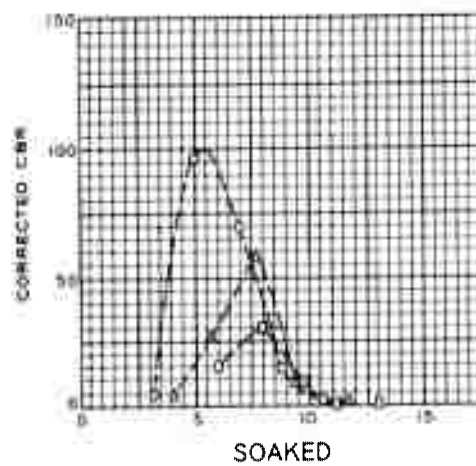
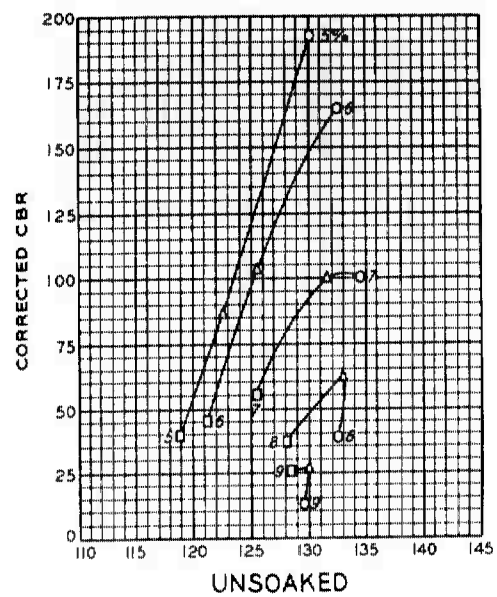
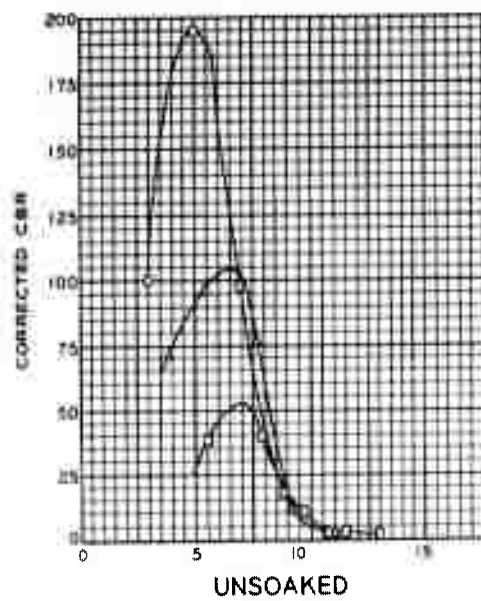
LEGEND

- O 55 BLOWS PER LAYER
- Δ 26 BLOWS PER LAYER
- 12 BLOWS PER LAYER

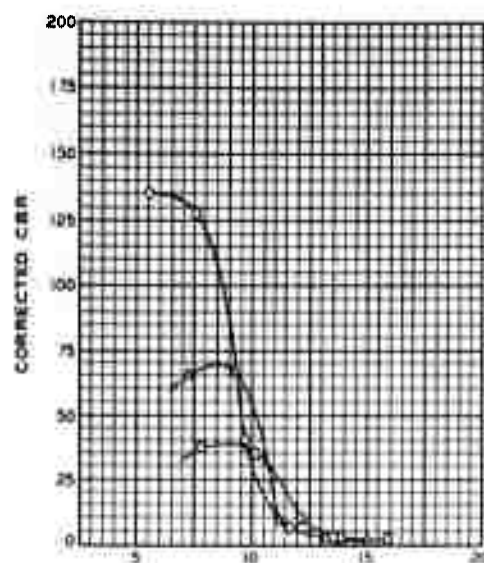
MOISTURE - DENSITY - CBR  
RELATIONS

KIRTLAND AFB  
SUBGRADE

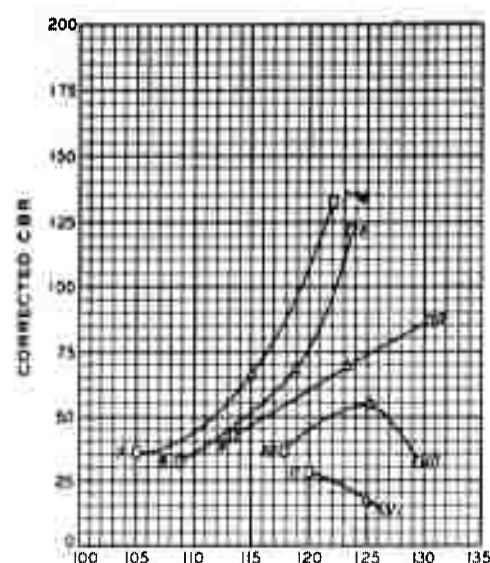
R 062955-5



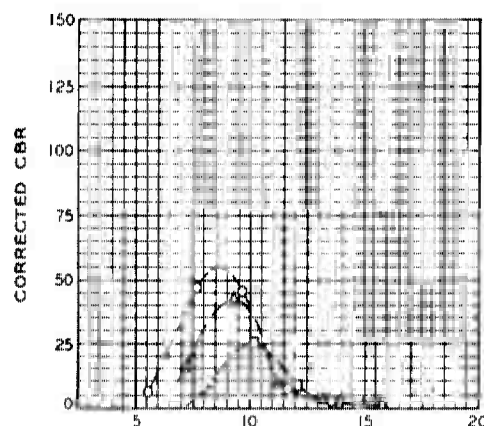
R 062955-Q



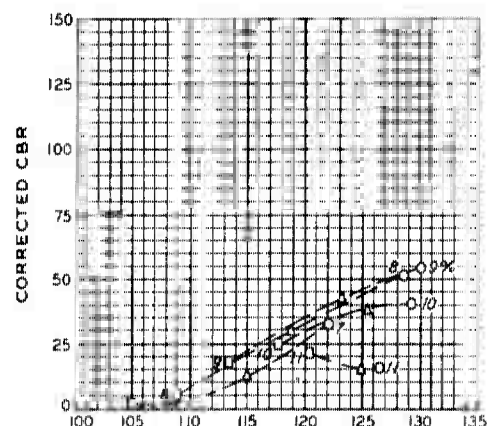
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UNSOAKED



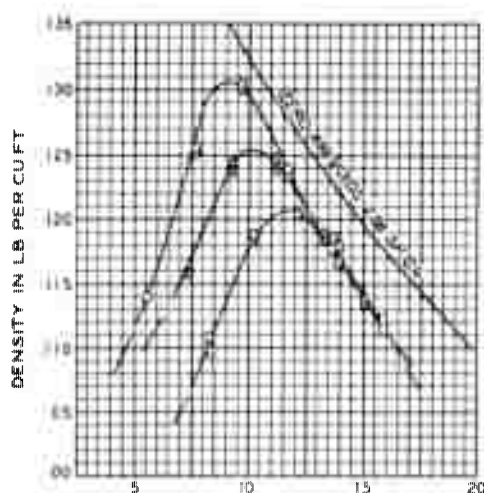
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MOLDED DRY DENSITY IN LB PER CU FT

SOAKED

DENSITY VS CBR



MOISTURE CONTENT IN PER CENT DRY WEIGHT

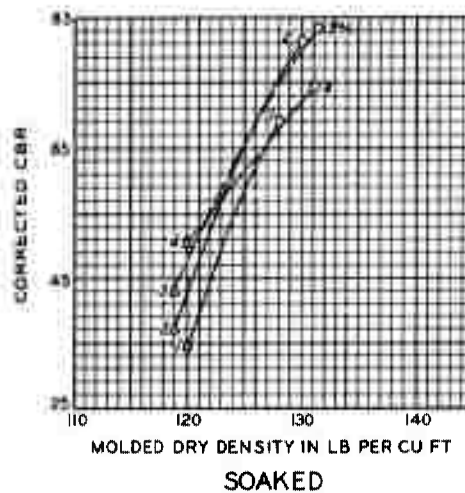
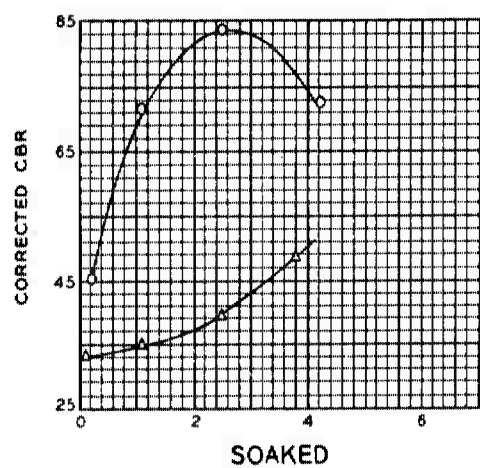
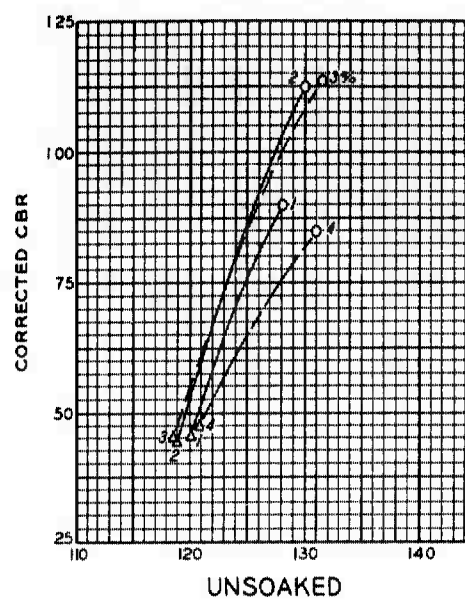
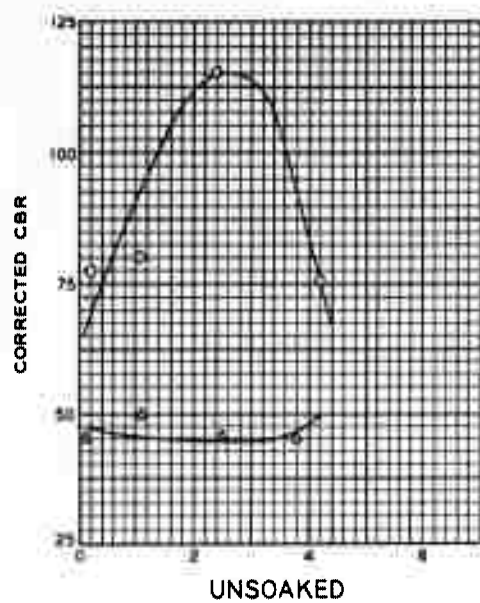
MOLDING MOISTURE CONTENT VS DENSITY AND CBR

- LEGEND
- 55 BLOWS PER LAYER
  - △ 26 BLOWS PER LAYER
  - 12 BLOWS PER LAYER

MOISTURE - DENSITY - CBR RELATIONS

CRAIG AFB  
SUBGRADE

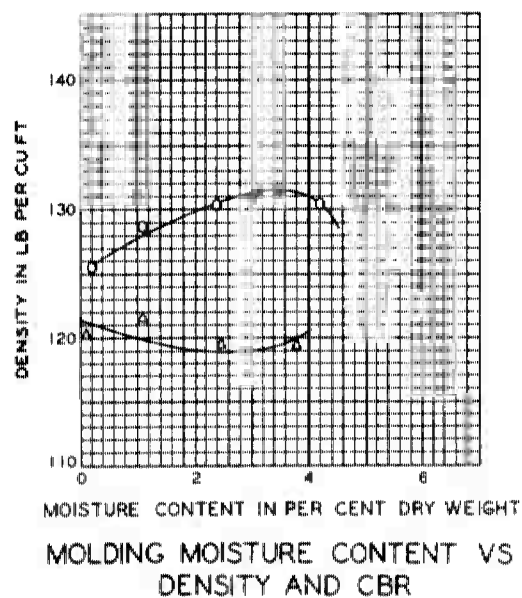
R 062935-T



### DENSITY VS CBR

#### LEGEND

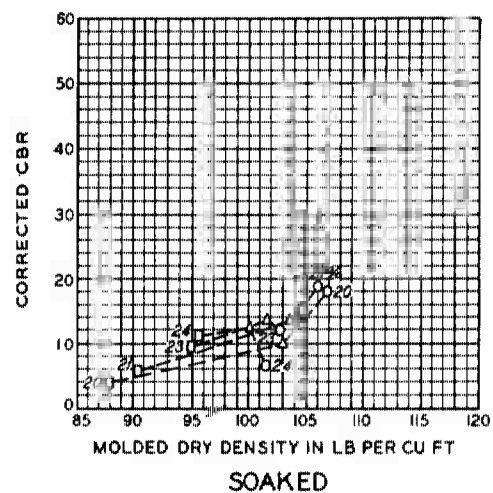
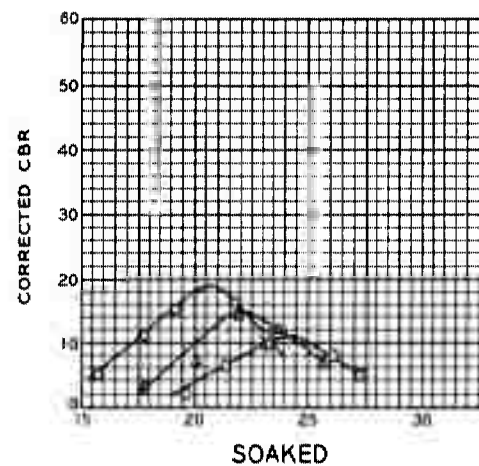
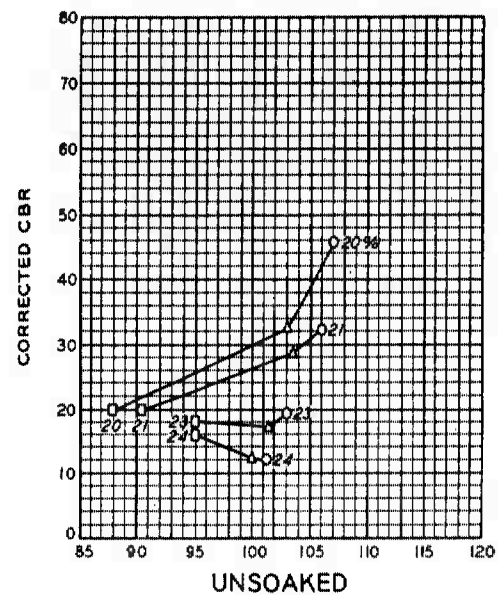
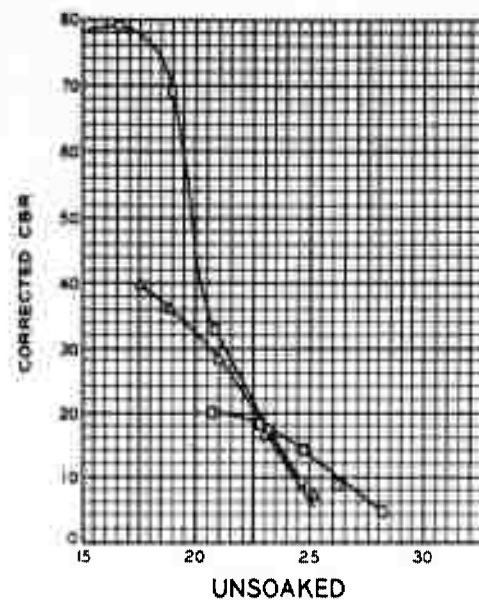
- O 55 BLOWS PER LAYER
- Δ 12 BLOWS PER LAYER



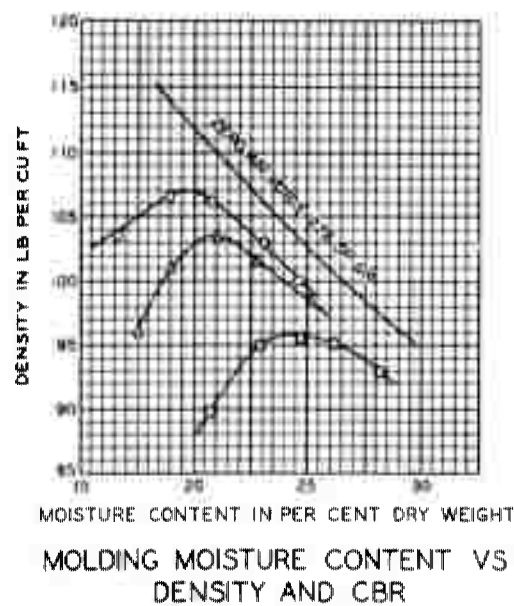
### MOISTURE - DENSITY - CBR RELATIONS

SEWART AFB  
BASE COURSE

R 062955-1



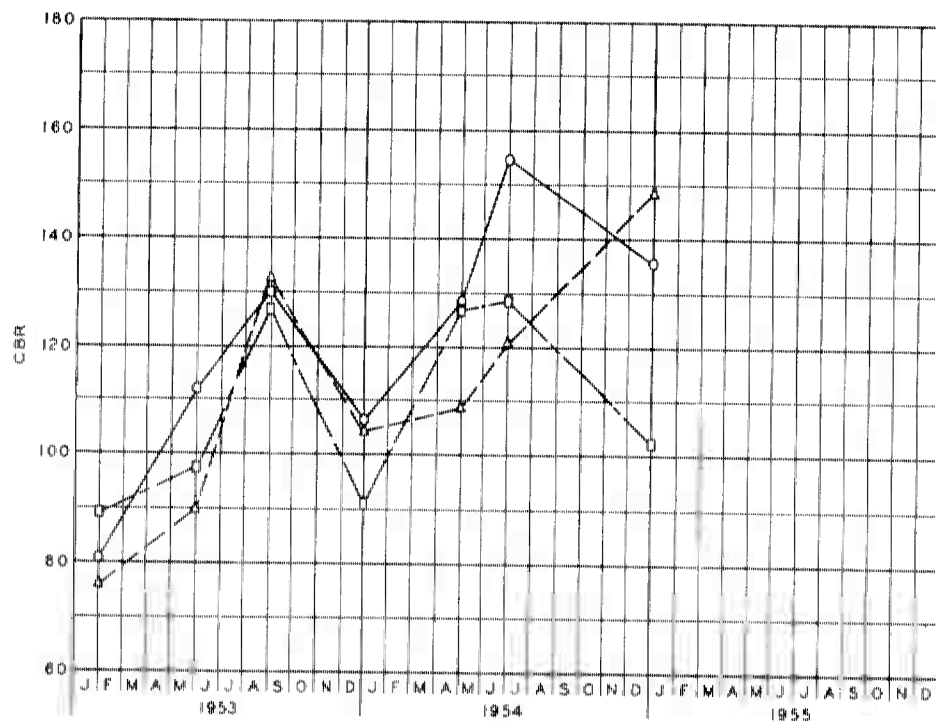
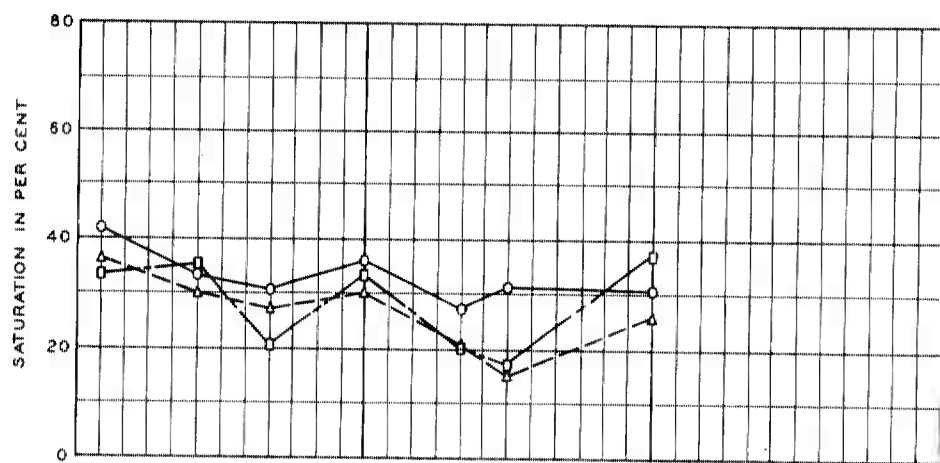
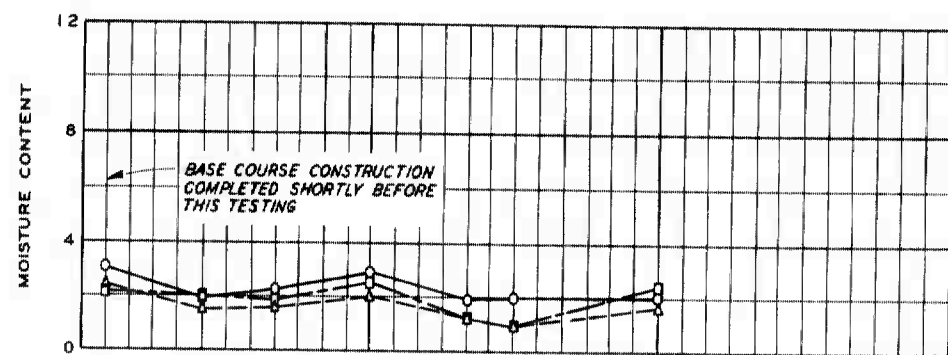
DENSITY VS CBR



LEGEND  
 O 55 BLOWS PER LAYER  
 Δ 26 BLOWS PER LAYER  
 □ 12 BLOWS PER LAYER

MOISTURE - DENSITY - CBR  
 RELATIONS  
 SEWART AFB  
 SUBGRADE

R 062955-U

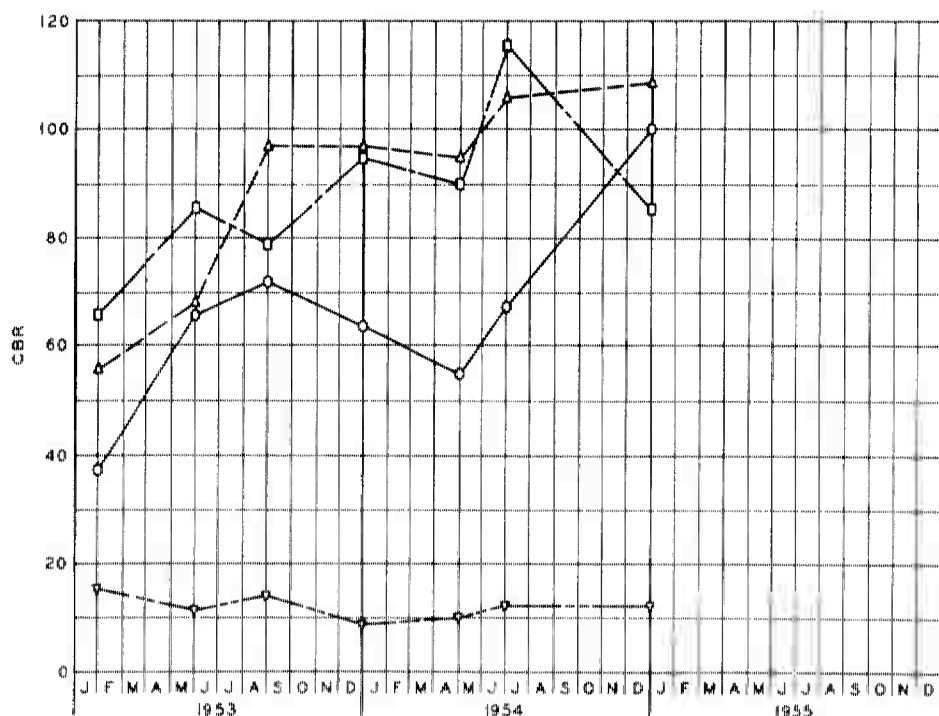
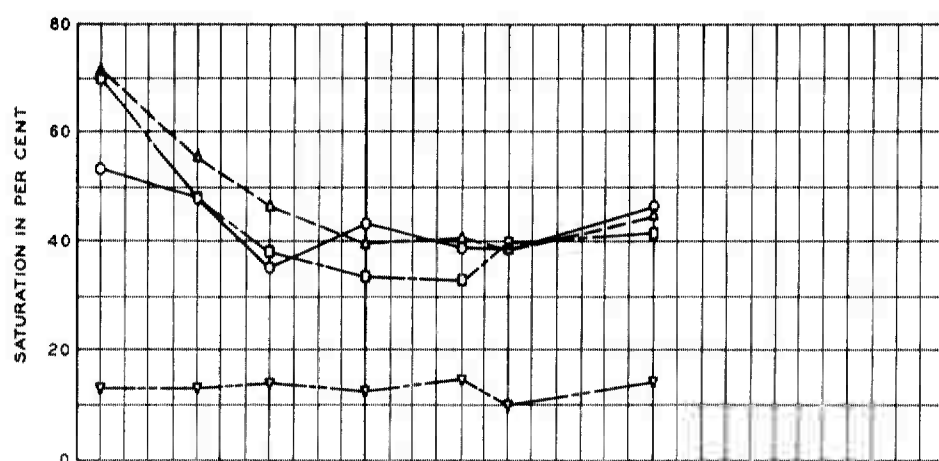
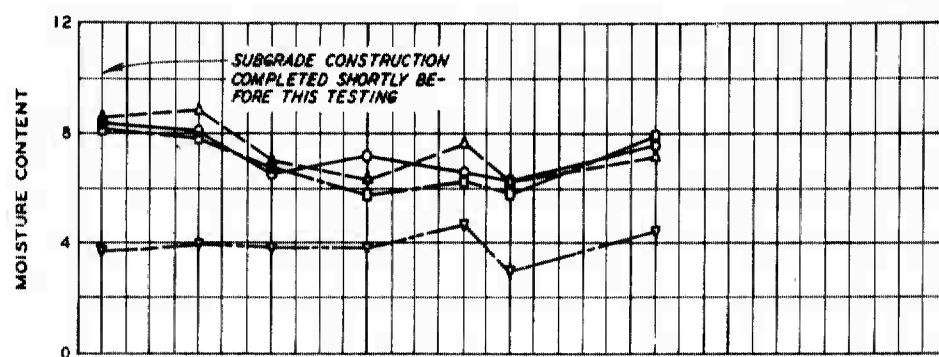


LEGEND

- LOCATION 1
- △ LOCATION 2
- LOCATION 3

VARIATIONS IN CONDITIONS  
WITH TIME  
KIRTLAND AFB SITE 2  
NORMAL LOCATIONS  
BASE COURSE

062955-W

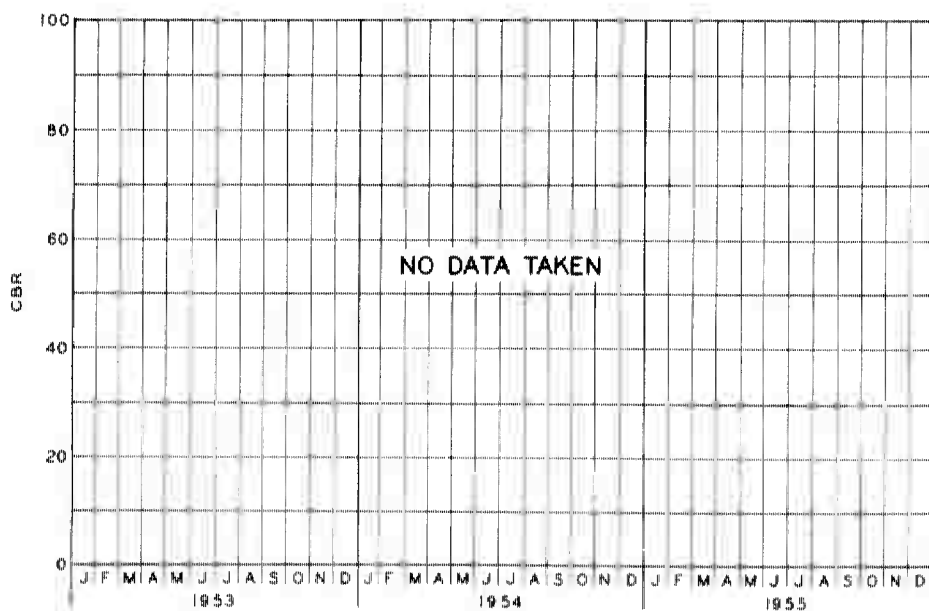
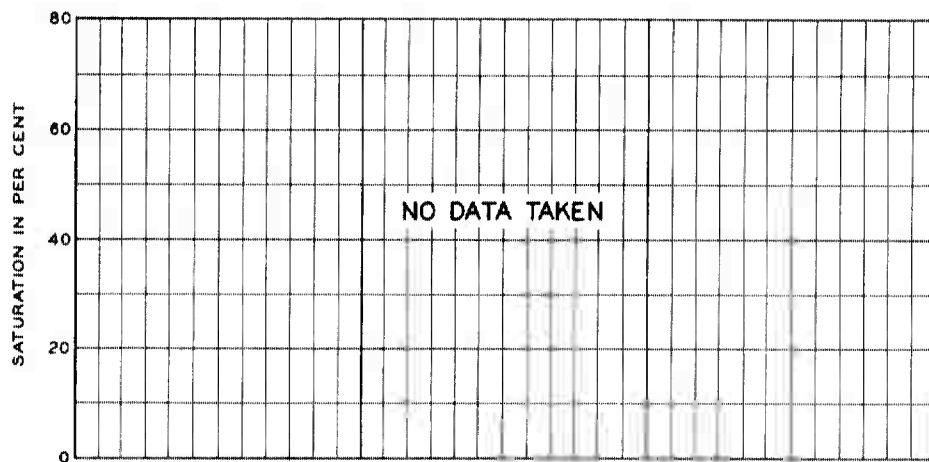
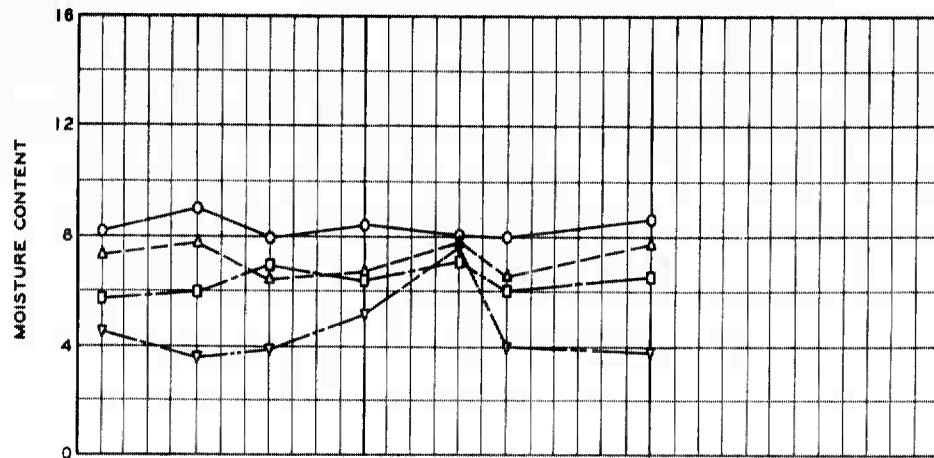


#### LEGEND

- LOCATION 1
- △ LOCATION 2
- LOCATION 3
- ▽ LOCATION 4

VARIATIONS IN CONDITIONS  
WITH TIME  
KIRTLAND AFB SITE 2  
NORMAL AND SHOULDER LOCATIONS  
SUBGRADE SURFACE

082955-X

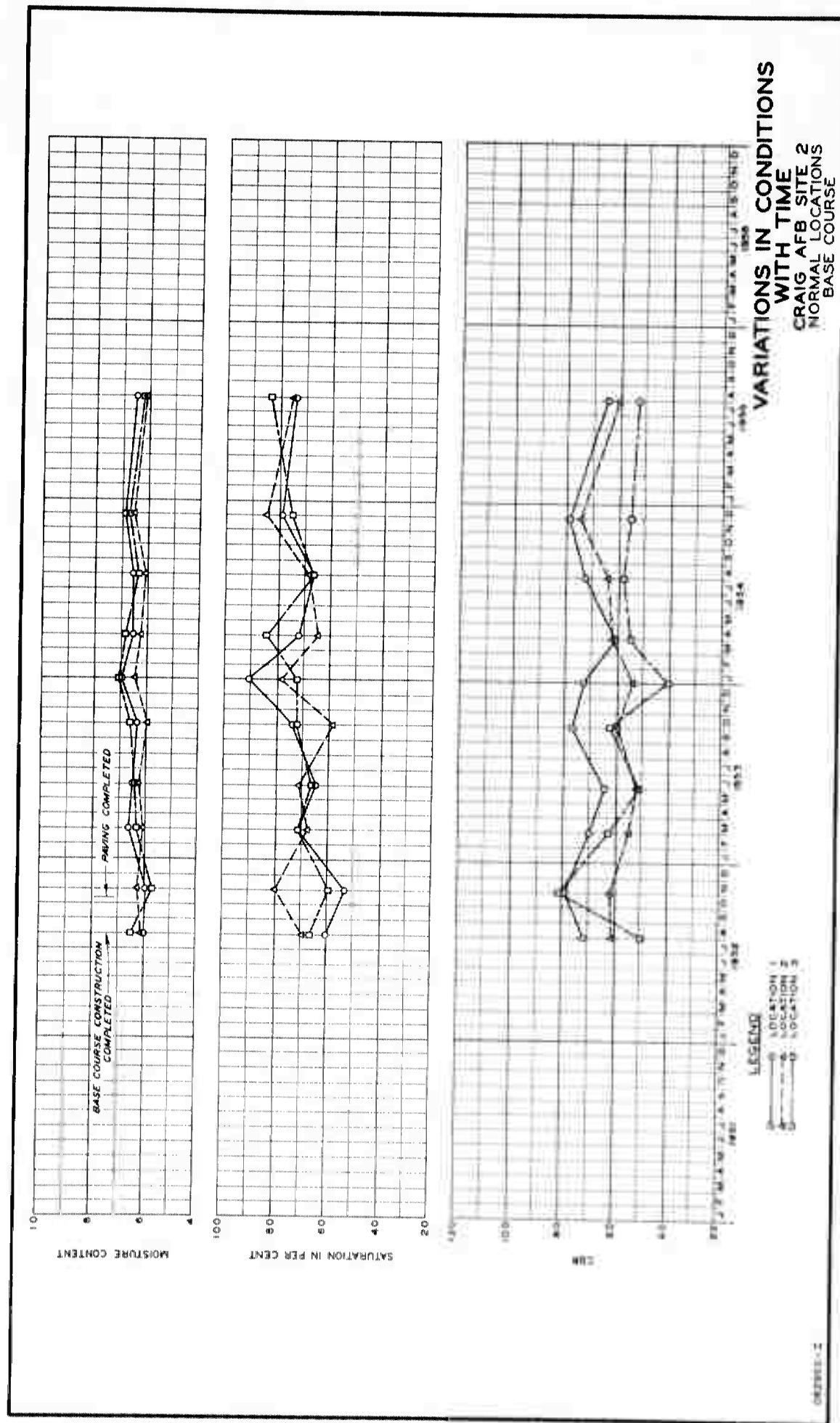


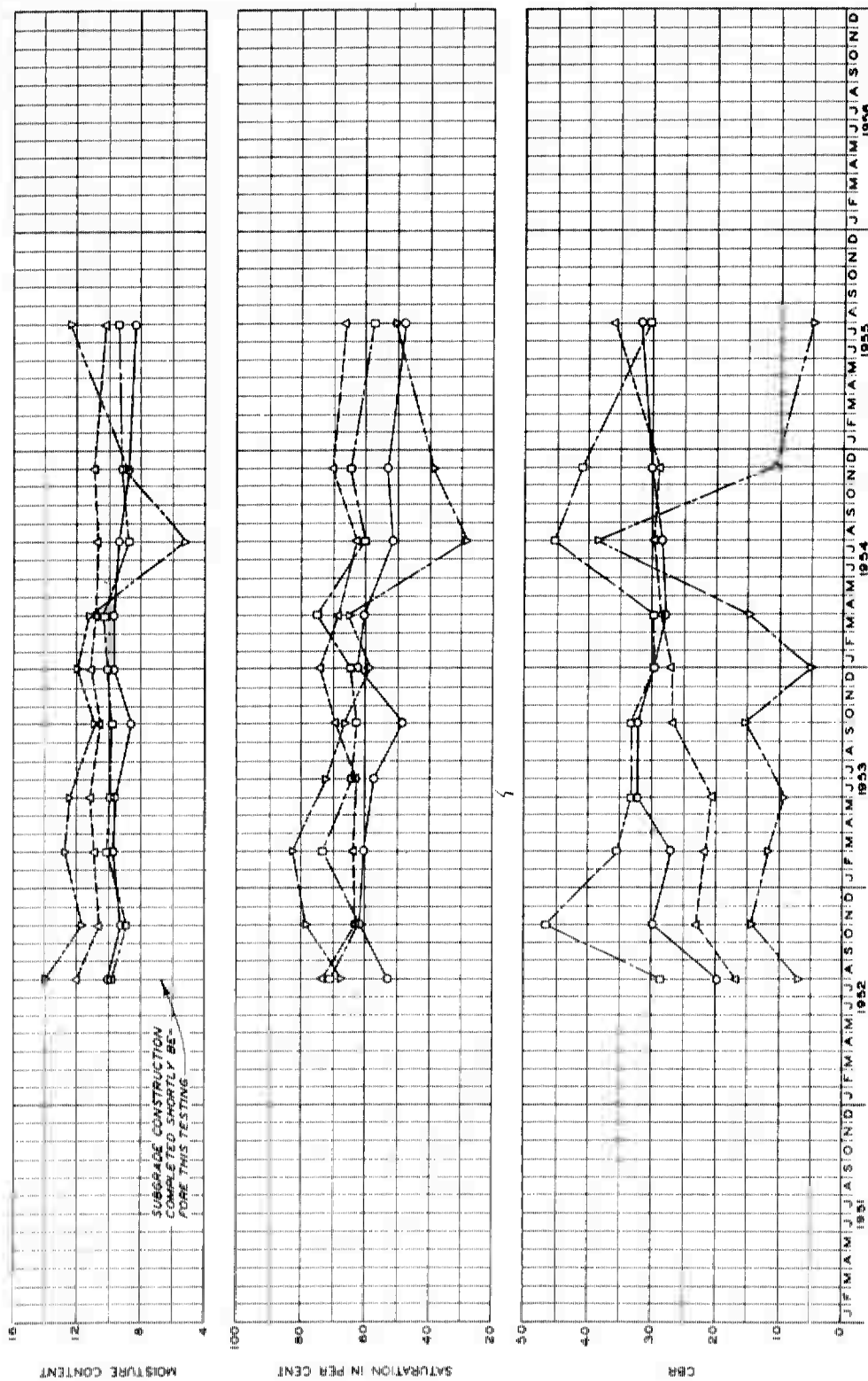
#### LEGEND

- LOCATION 1
- △ LOCATION 2
- LOCATION 3
- ◇ LOCATION 4

VARIATIONS IN CONDITIONS  
WITH TIME  
KIRTLAND AFB SITE 2  
NORMAL AND SHOULDER LOCATIONS  
SUBGRADE 18-IN. DEPTH

062955-Y



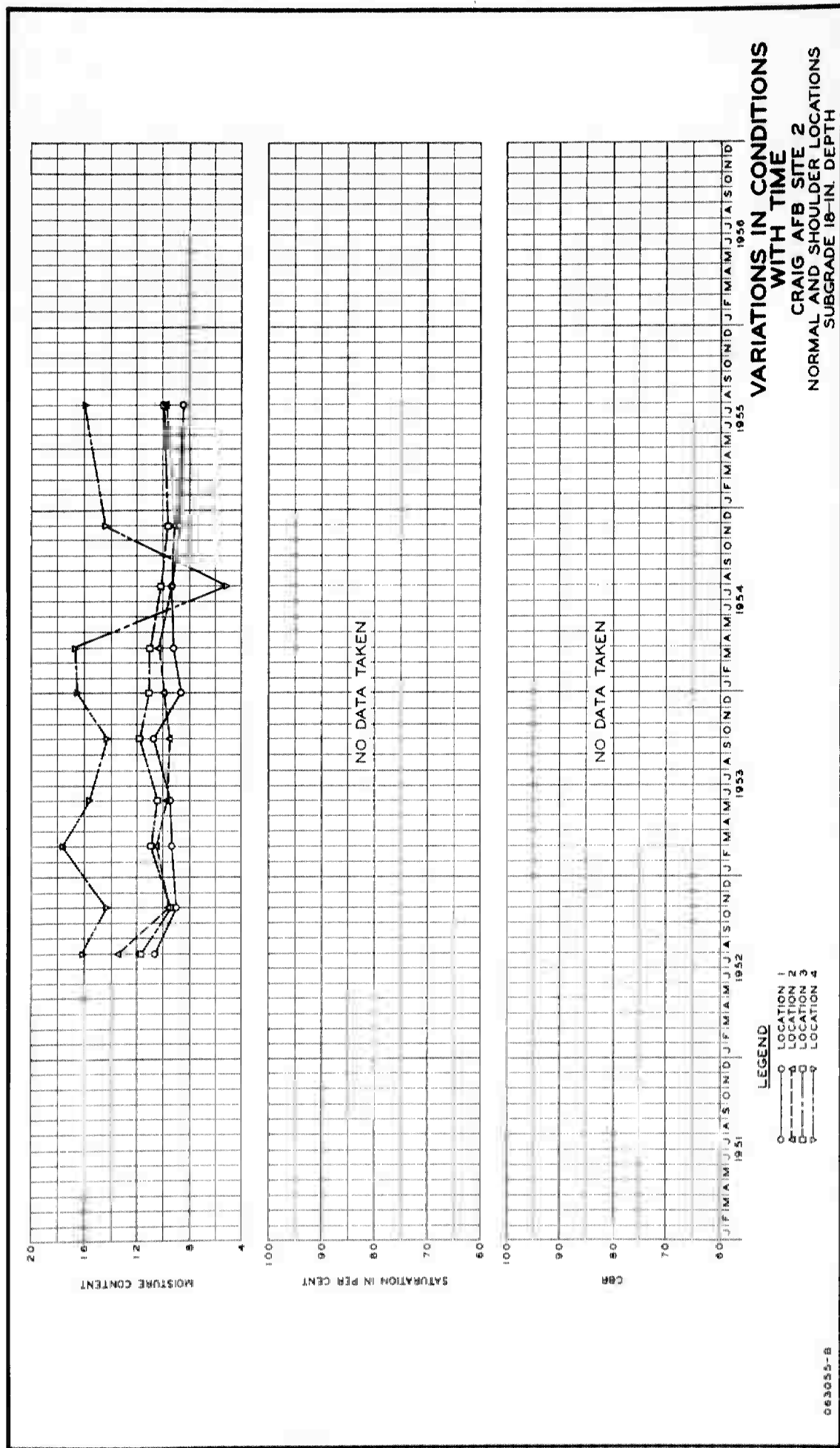


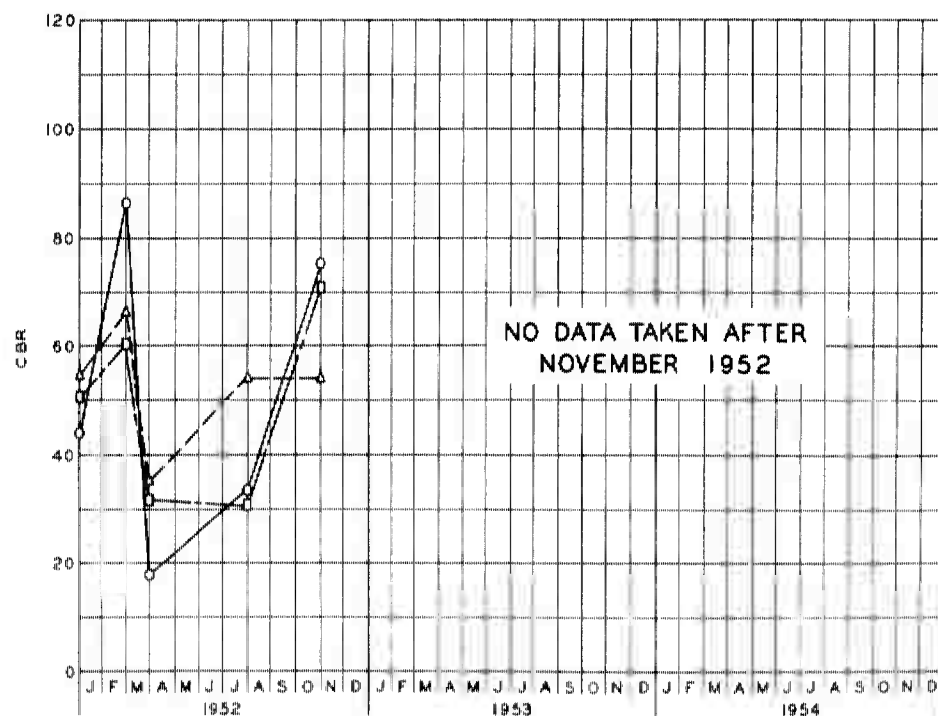
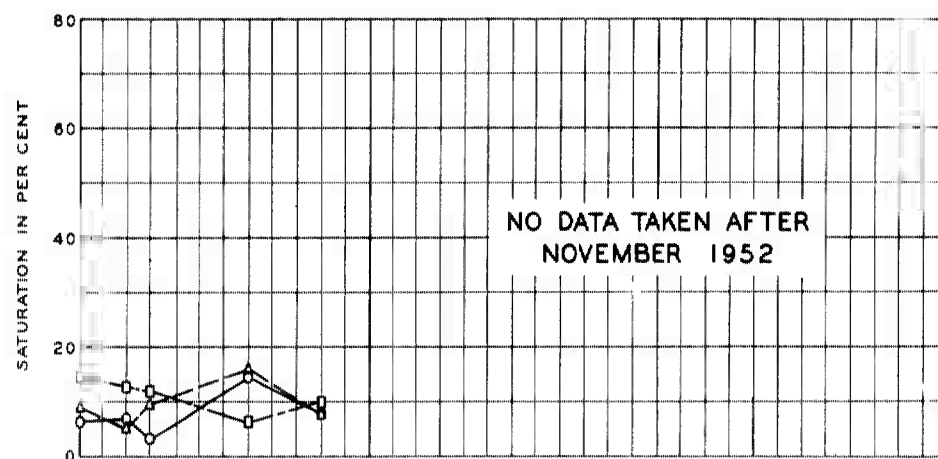
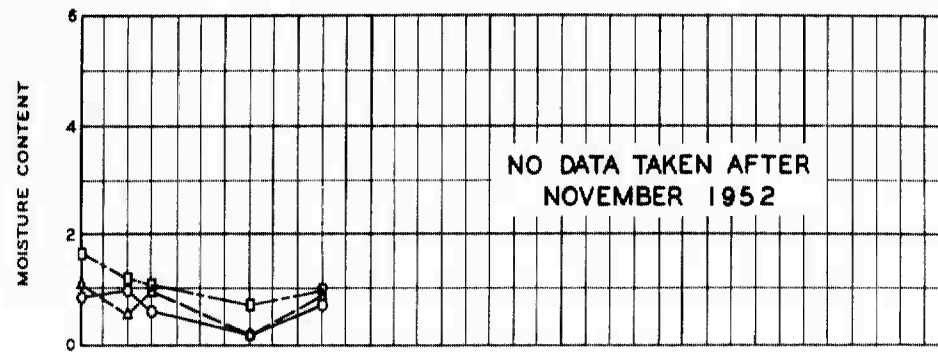
**VARIATIONS IN CONDITIONS WITH TIME**  
**CRAIG AFB SITE 2**  
**NORMAL AND SHOULDER LOCATIONS**  
**SUBGRADE SURFACE**

**LEGEND**

- LOCATION 1
- LOCATION 2
- △ LOCATION 3
- △ LOCATION 4

063055-A



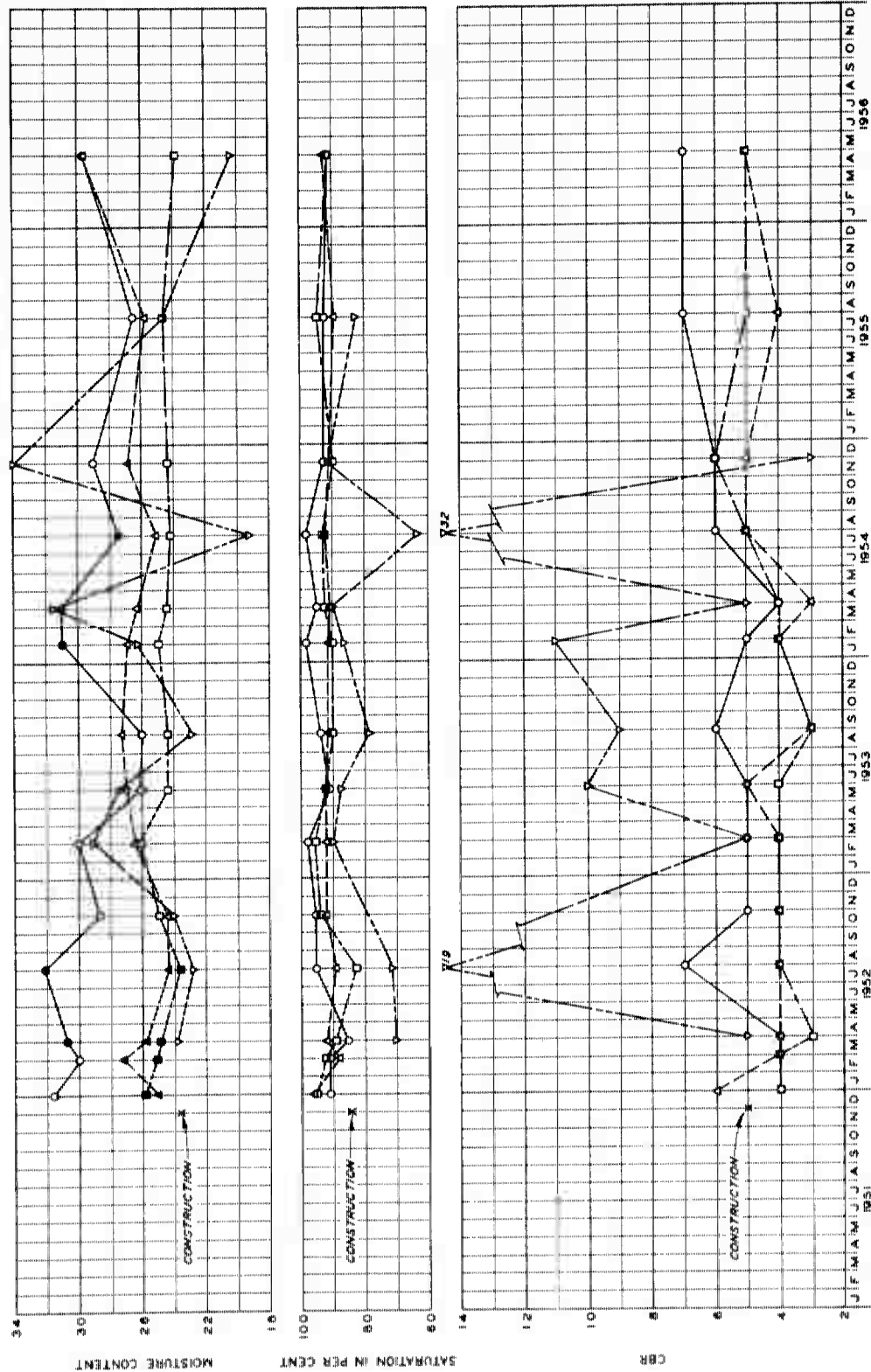


#### LEGEND

- LOCATION 1
- △ LOCATION 2
- LOCATION 3

VARIATIONS IN CONDITIONS  
WITH TIME  
SEWART AFB  
NORMAL LOCATIONS  
BASE COURSE

031154-A

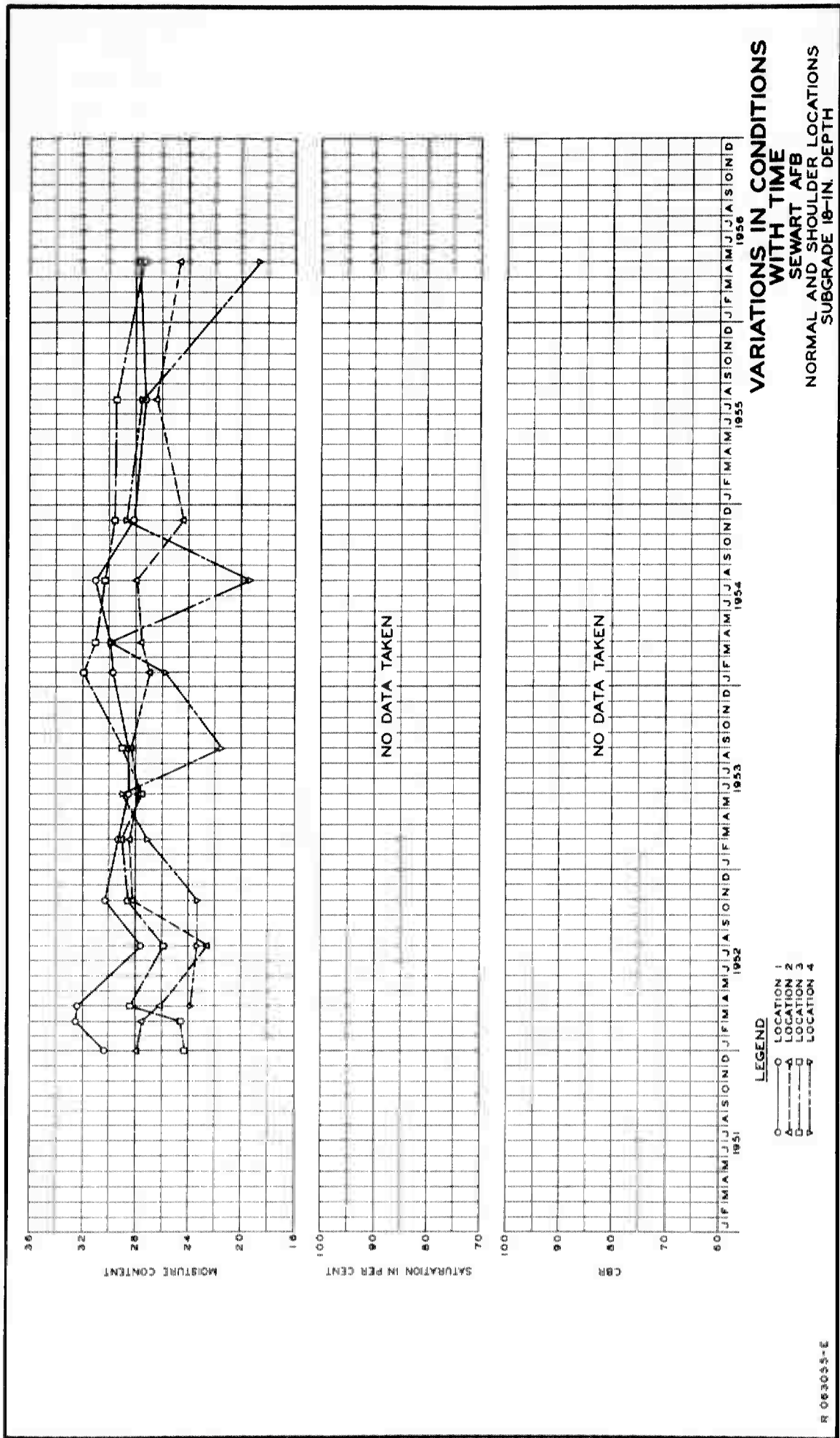


# VARIATIONS IN CONDITIONS WITH TIME

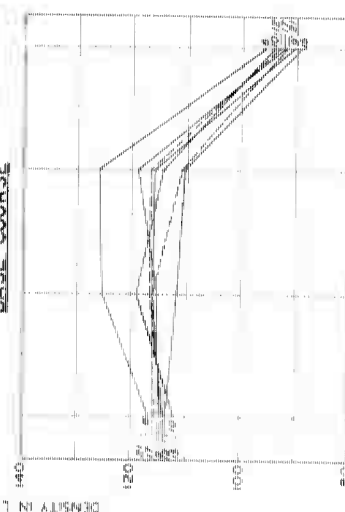
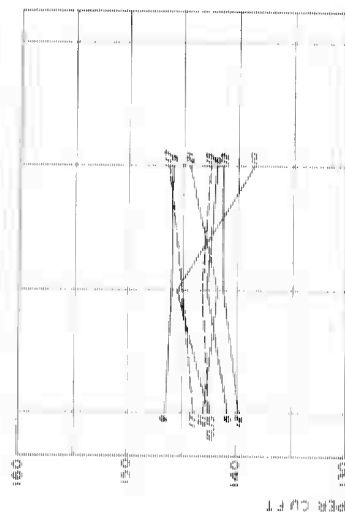
SEWART AFB  
NORMAL AND SHOULDER LOCATIONS  
SUBGRADE SURFACE

LEGEND  
 O LOCATION 1  
 Δ LOCATION 2  
 □ LOCATION 3  
 ◇ LOCATION 4  
 CLOSED SYMBOLS INDICATE FREE WATER

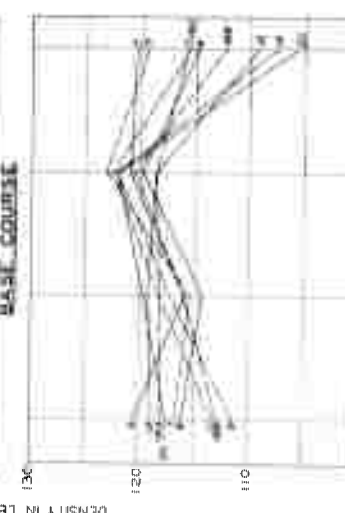
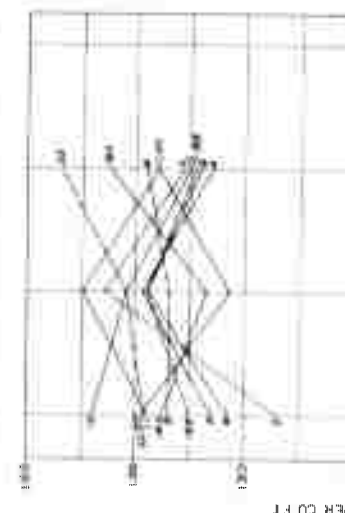
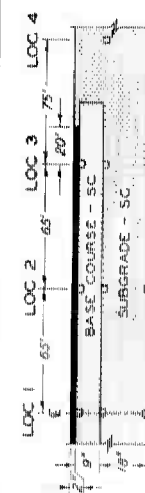
R 063055-D



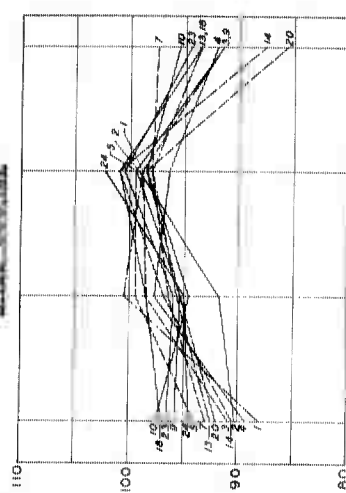
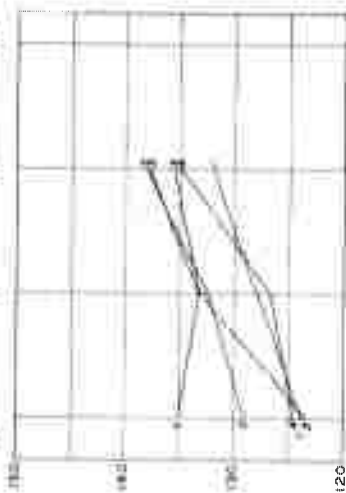
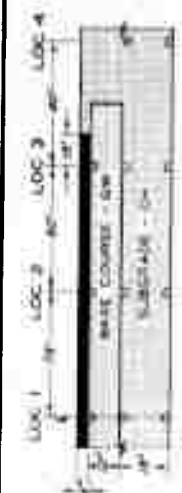




KIRTLAND AFB SITE 2



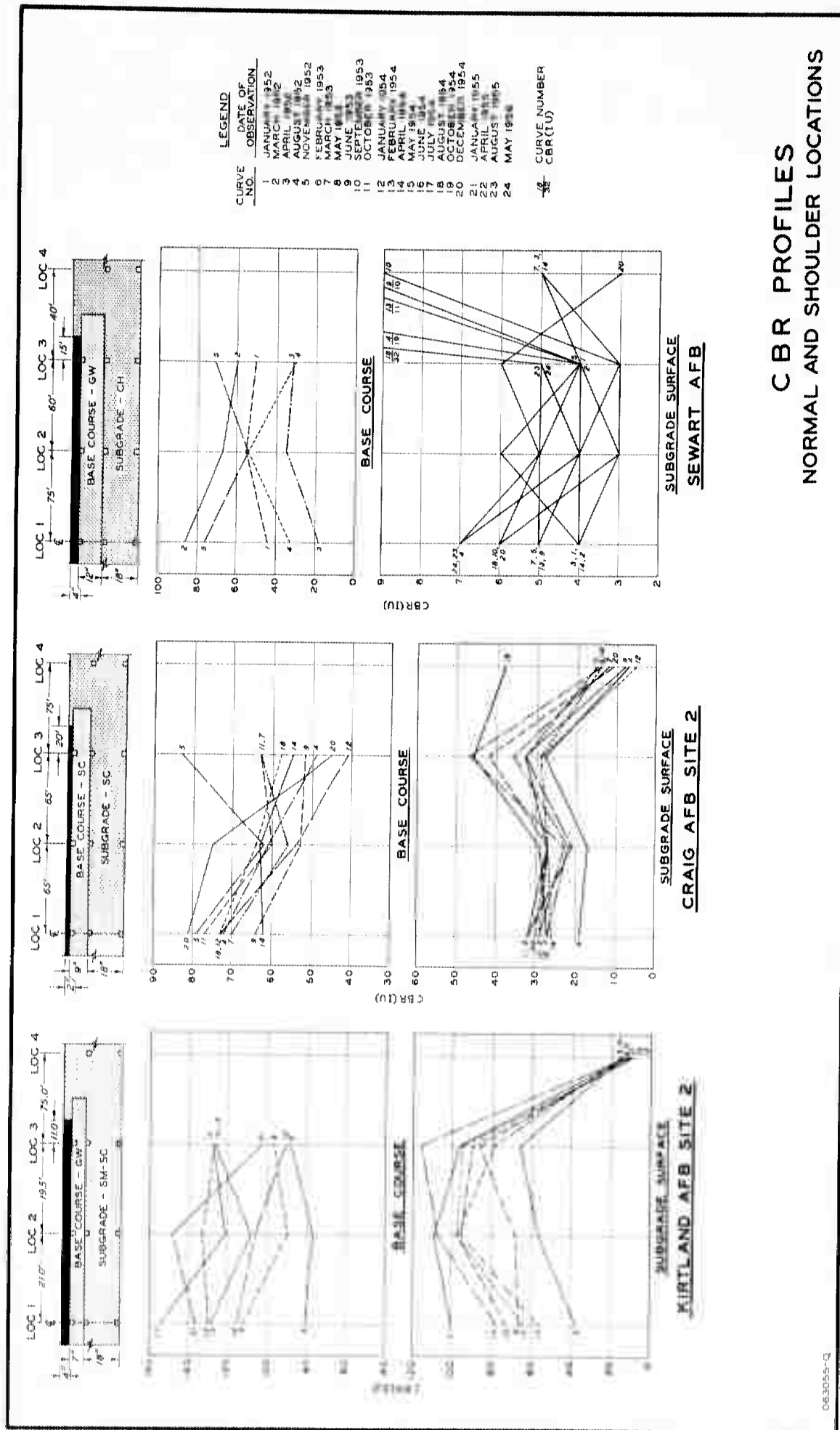
CRAIG AFB SITE 2

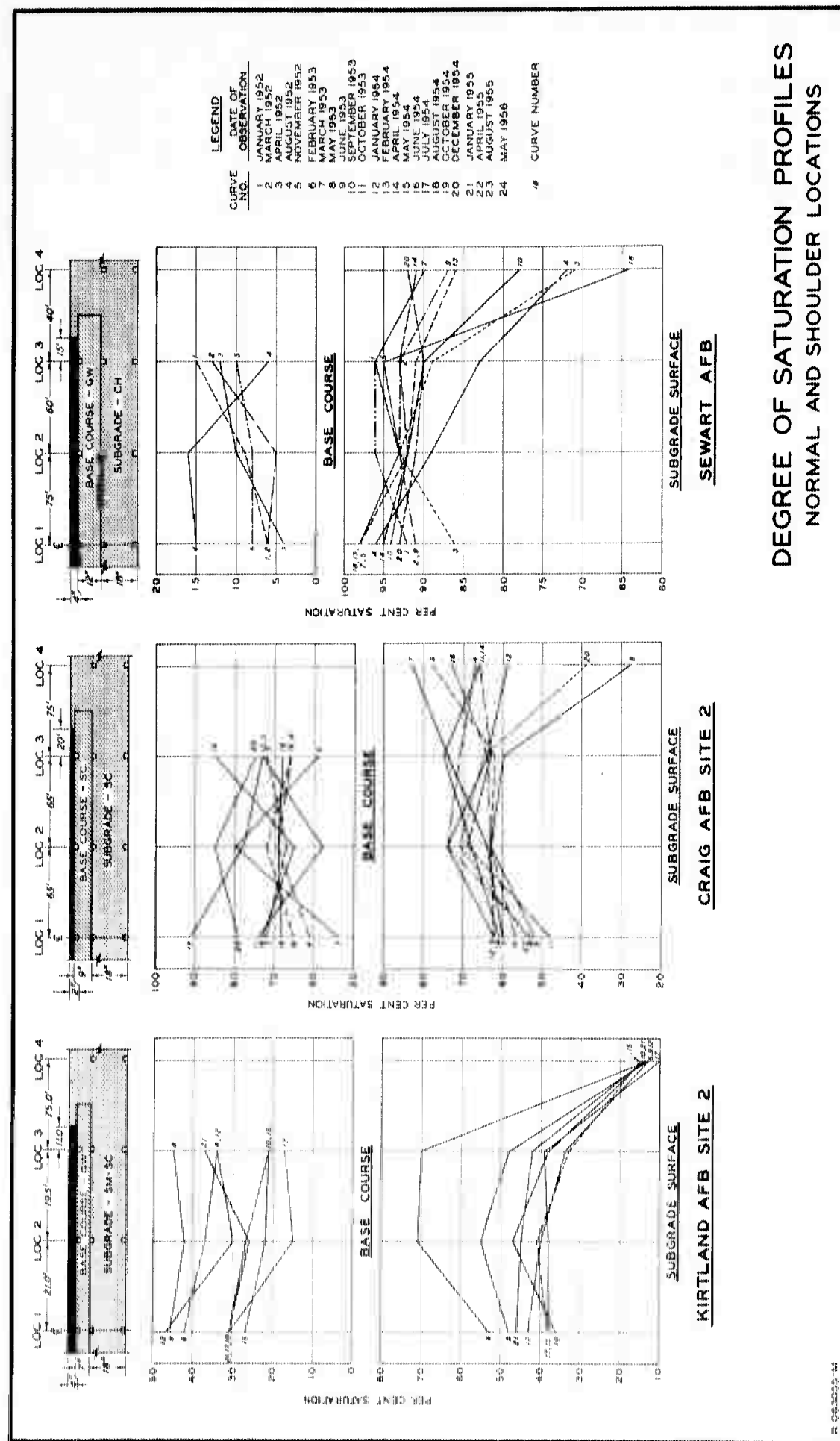


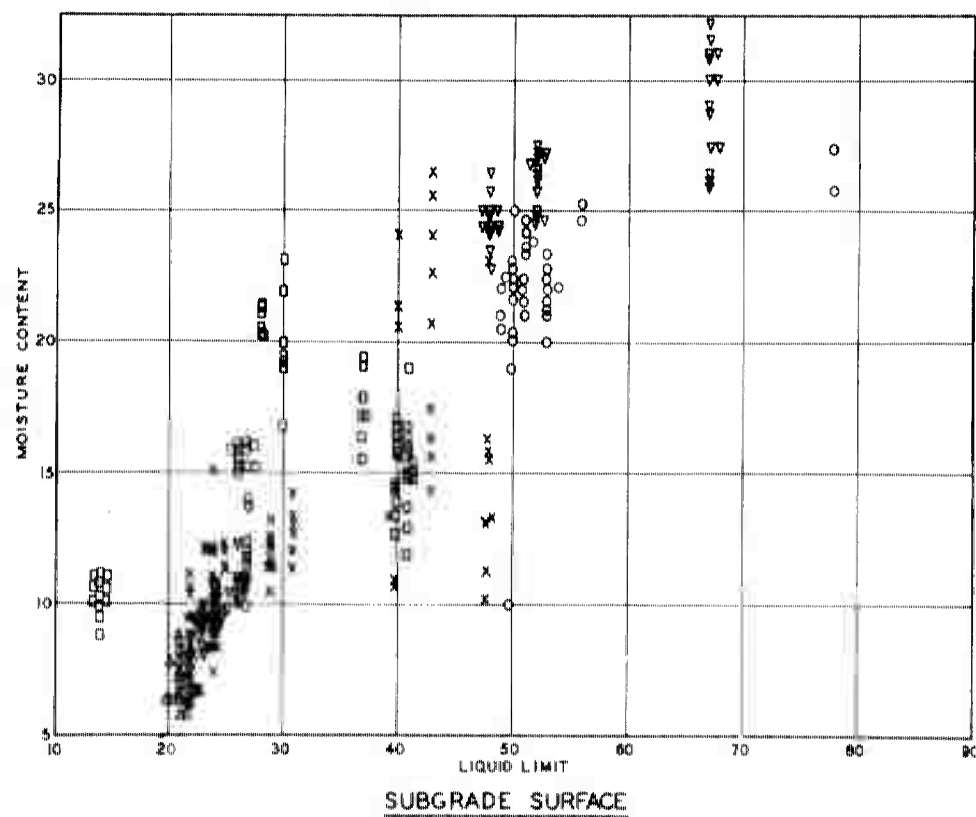
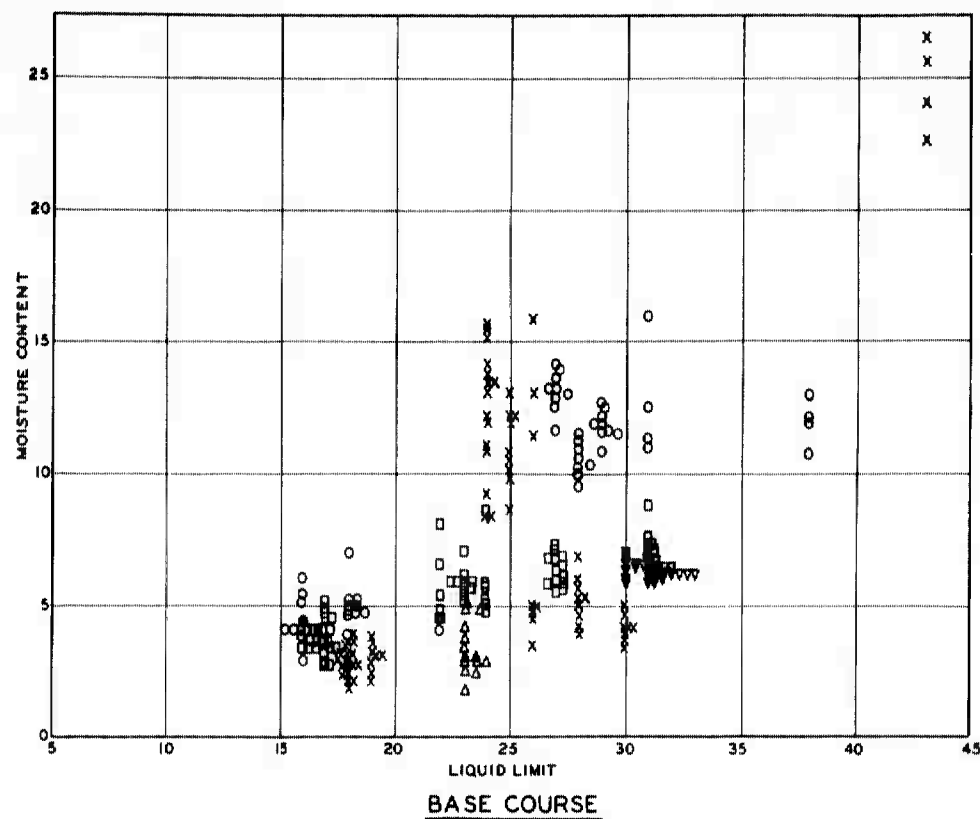
SEWART AFB

CURVE NO.	LEGEND	
	DATE OF OBSERVATION	CURVE NUMBER
1	JANUARY 1952	1
2	MARCH 1952	2
3	APRIL 1952	3
4	AUGUST 1952	4
5	NOVEMBER 1952	5
6	FEBRUARY 1953	6
7	MARCH 1953	7
8	MAY 1953	8
9	SEPTEMBER 1953	9
10	OCTOBER 1953	10
11	JANUARY 1954	11
12	FEBRUARY 1954	12
13	APRIL 1954	13
14	MAY 1954	14
15	JUNE 1954	15
16	JULY 1954	16
17	AUGUST 1954	17
18	SEPTEMBER 1954	18
19	OCTOBER 1954	19
20	NOVEMBER 1954	20
21	JANUARY 1955	21
22	APRIL 1955	22
23	AUGUST 1955	23
24	MAY 1956	24
18		

# DENSITY PROFILES NORMAL AND SHOULDER LOCATIONS







**LEGEND**

1945-1952

- X LOW RAINFALL ZONE
- O MEDIUM RAINFALL ZONE
- HIGH RAINFALL ZONE

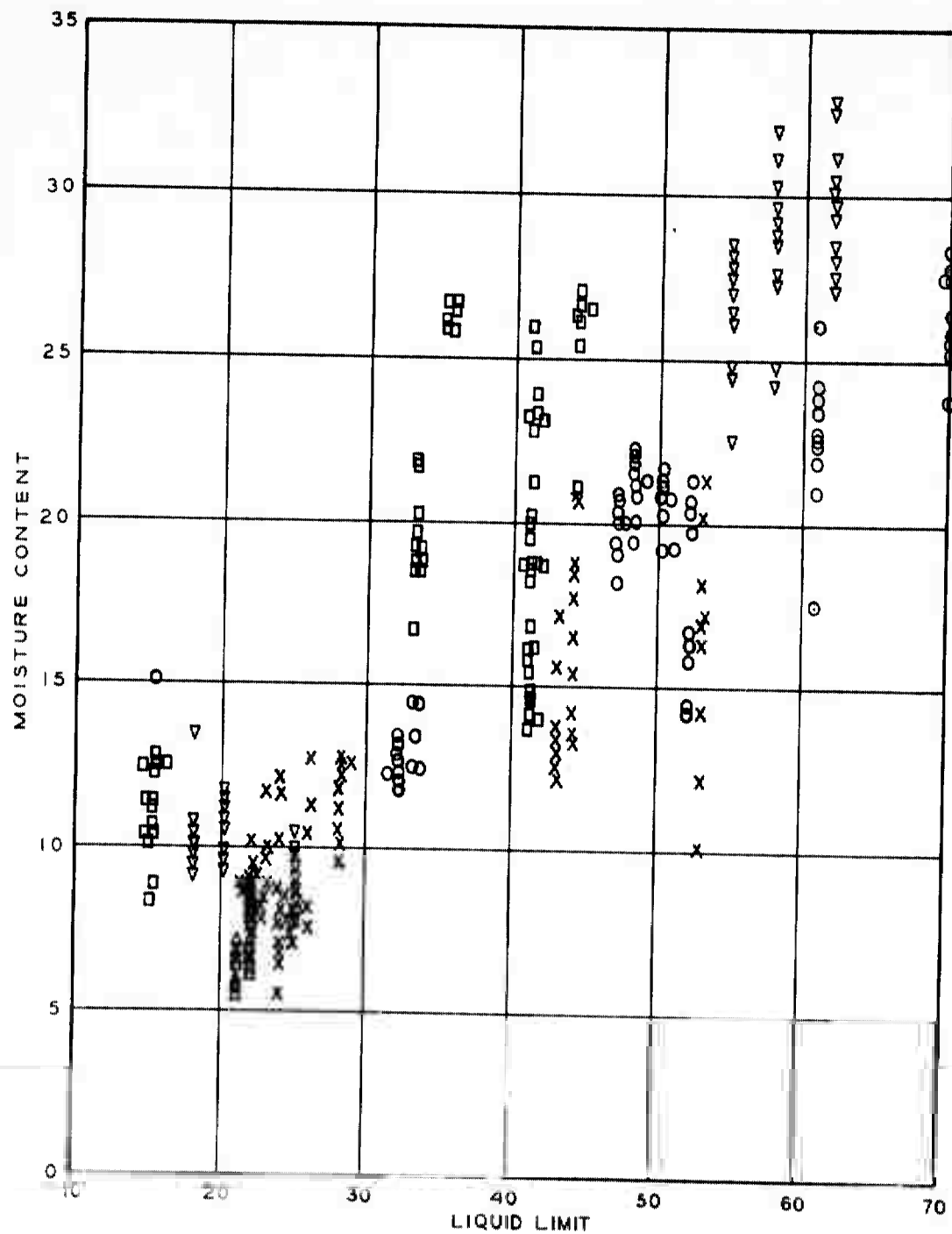
1952-1956

- Δ
- ▽

NOTE THE VALUES SHOWN ARE AVERAGE  
MOISTURE CONTENTS FOR EACH  
PATTERN AT EACH TESTING

**MOISTURE CONTENT VS  
LIQUID LIMIT  
NORMAL LOCATIONS  
BASE AND SUBGRADE SURFACE**

R 032652-H

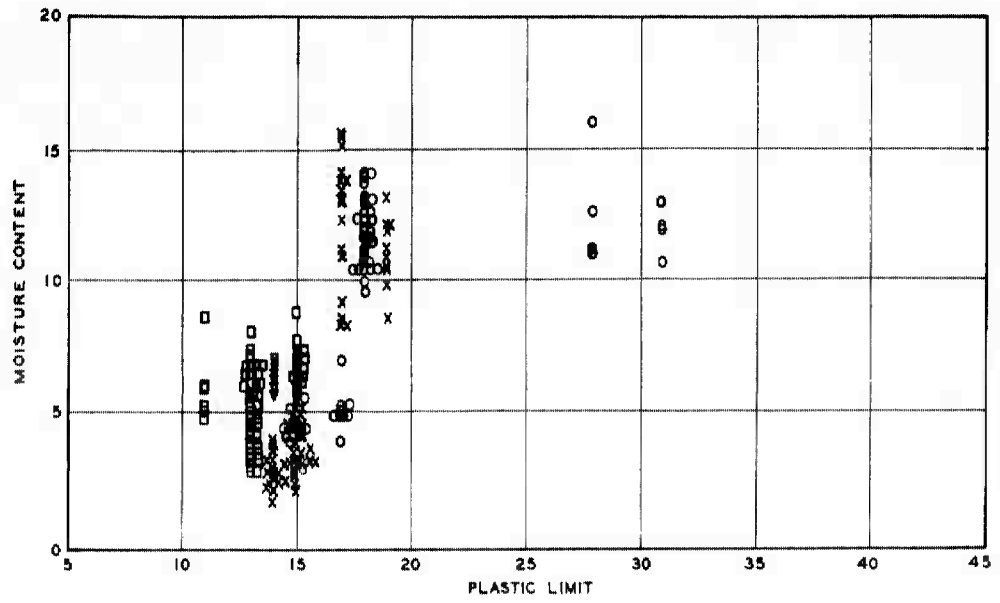


LEGEND  
 1945-1952 1952-1956  
 x LOW RAINFALL ZONE Δ  
 o MEDIUM RAINFALL ZONE ◊  
 □ HIGH RAINFALL ZONE ▽

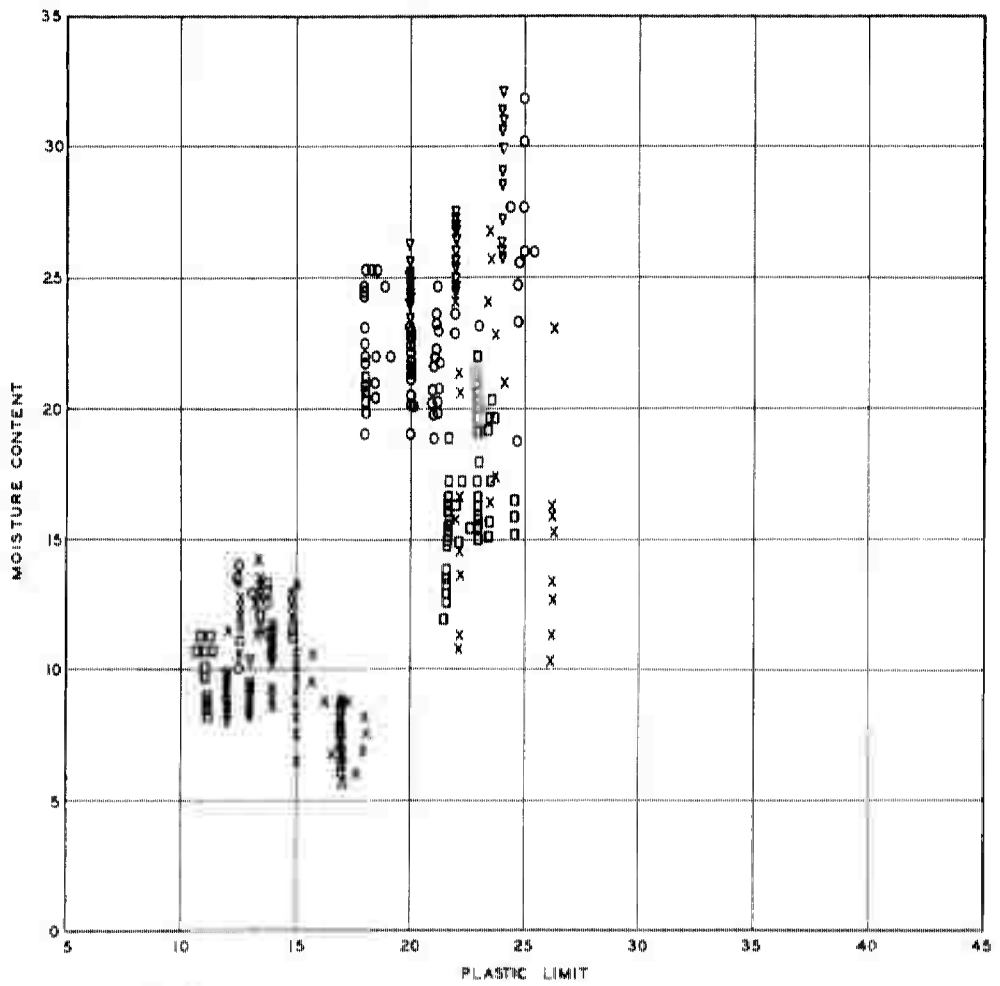
NOTE THE VALUES SHOWN ARE AVERAGE  
 MOISTURE CONTENTS FOR EACH  
 PATTERN AT EACH TESTING

MOISTURE CONTENT VS  
 LIQUID LIMIT  
 NORMAL LOCATIONS  
 SUBGRADE-18" DEPTH

R 012654-A



BASE COURSE



LEGEND

SUBGRADE SURFACE

1945-1952

1952-1956

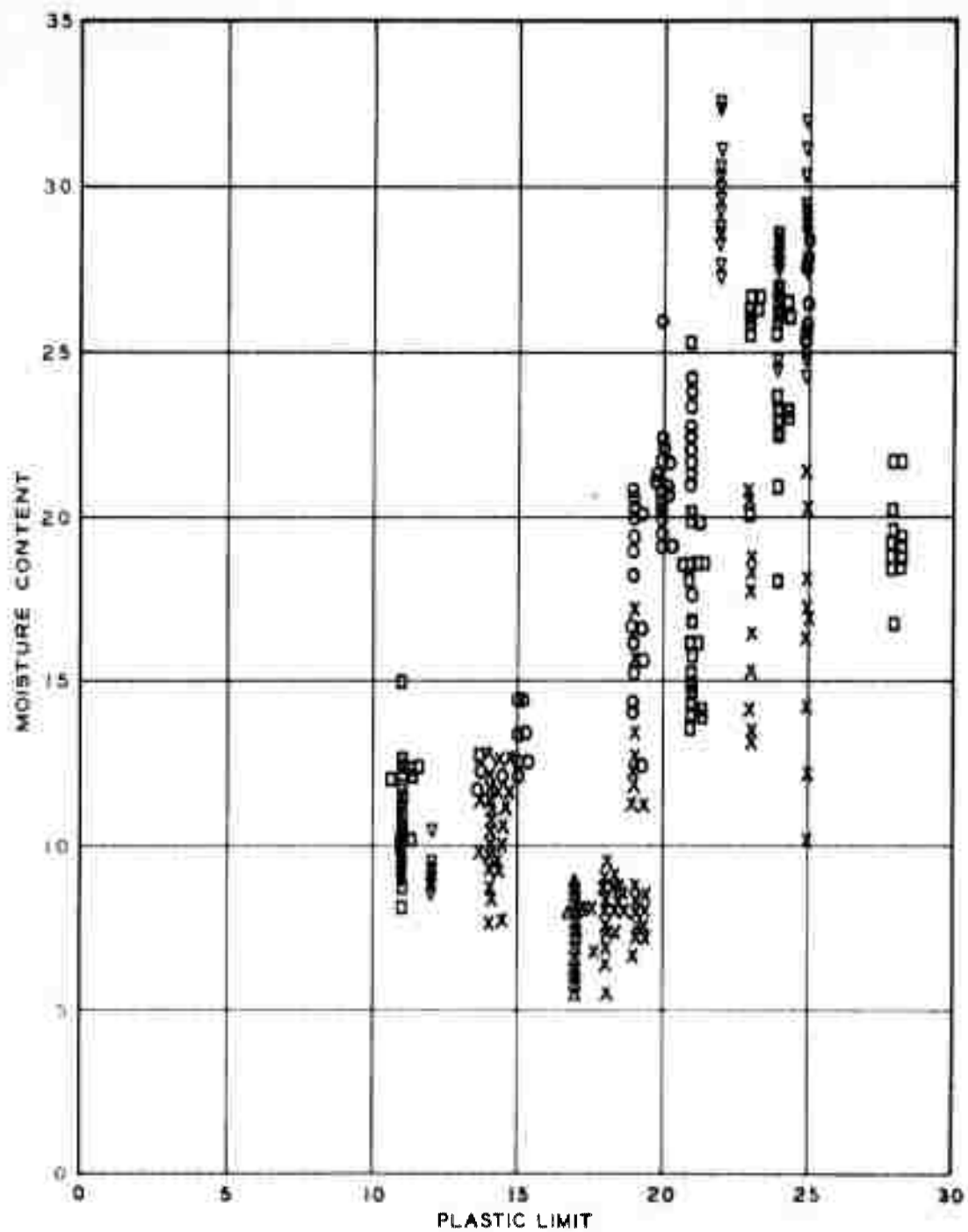
- |   |                      |   |
|---|----------------------|---|
| X | LOW RAINFALL ZONE    | Δ |
| O | MEDIUM RAINFALL ZONE |   |
| D | HIGH RAINFALL ZONE   | ▽ |

NOTE THE VALUES SHOWN ARE AVERAGE  
MOISTURE CONTENTS FOR EACH  
PATTERN AT EACH TESTING

R 081553-H

MOISTURE CONTENT VS  
PLASTIC LIMIT

NORMAL LOCATIONS  
BASE AND SUBGRADE SURFACE



LEGEND

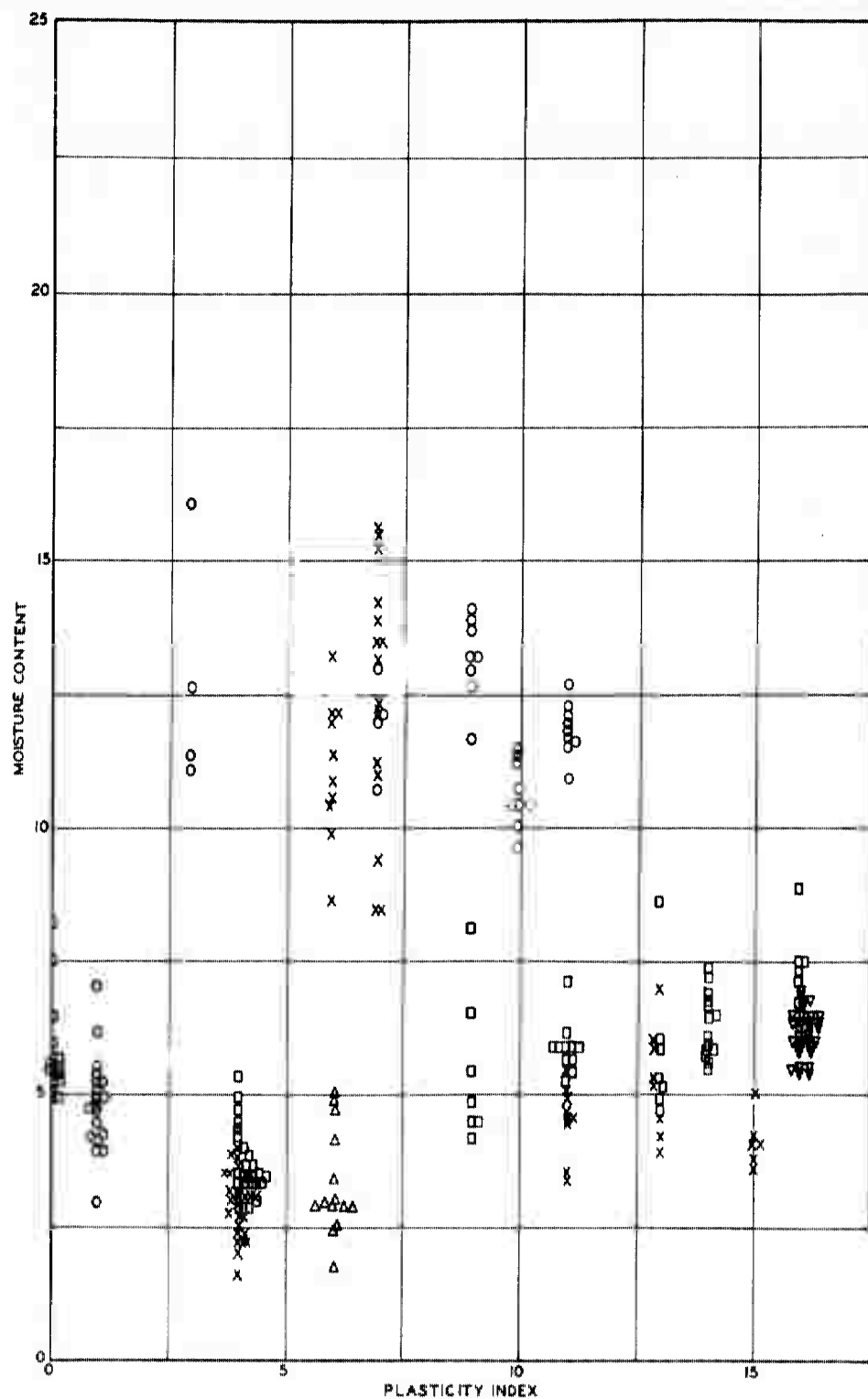
1945-1952		1952-1956
x	LOW RAINFALL ZONE	Δ
o	MEDIUM RAINFALL ZONE	
□	HIGH RAINFALL ZONE	▽

NOTE THE VALUES SHOWN ARE AVERAGE  
MOISTURE CONTENTS FOR EACH  
PATTERN AT EACH TESTING

### MOISTURE CONTENT VS PLASTIC LIMIT

NORMAL LOCATIONS  
SUBGRADE-18" DEPTH

R012854-C



#### LEGEND

1945-1952

- X LOW RAINFALL ZONE
- O MEDIUM RAINFALL ZONE
- HIGH RAINFALL ZONE

1952-1956

- Δ
- ▽

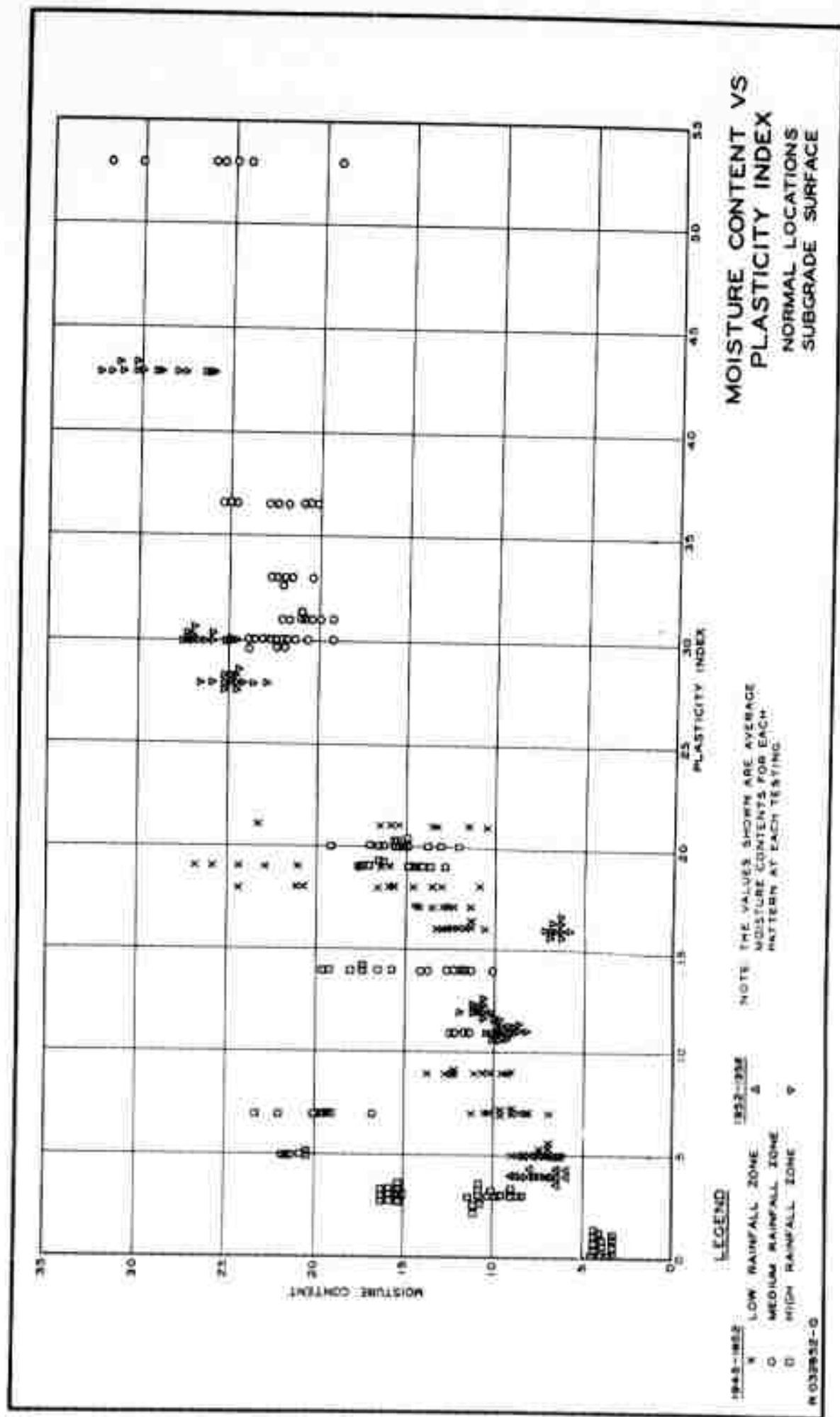
NOTE THE VALUES SHOWN ARE AVERAGE  
MOISTURE CONTENTS FOR EACH  
PATTERN AT EACH TESTING.

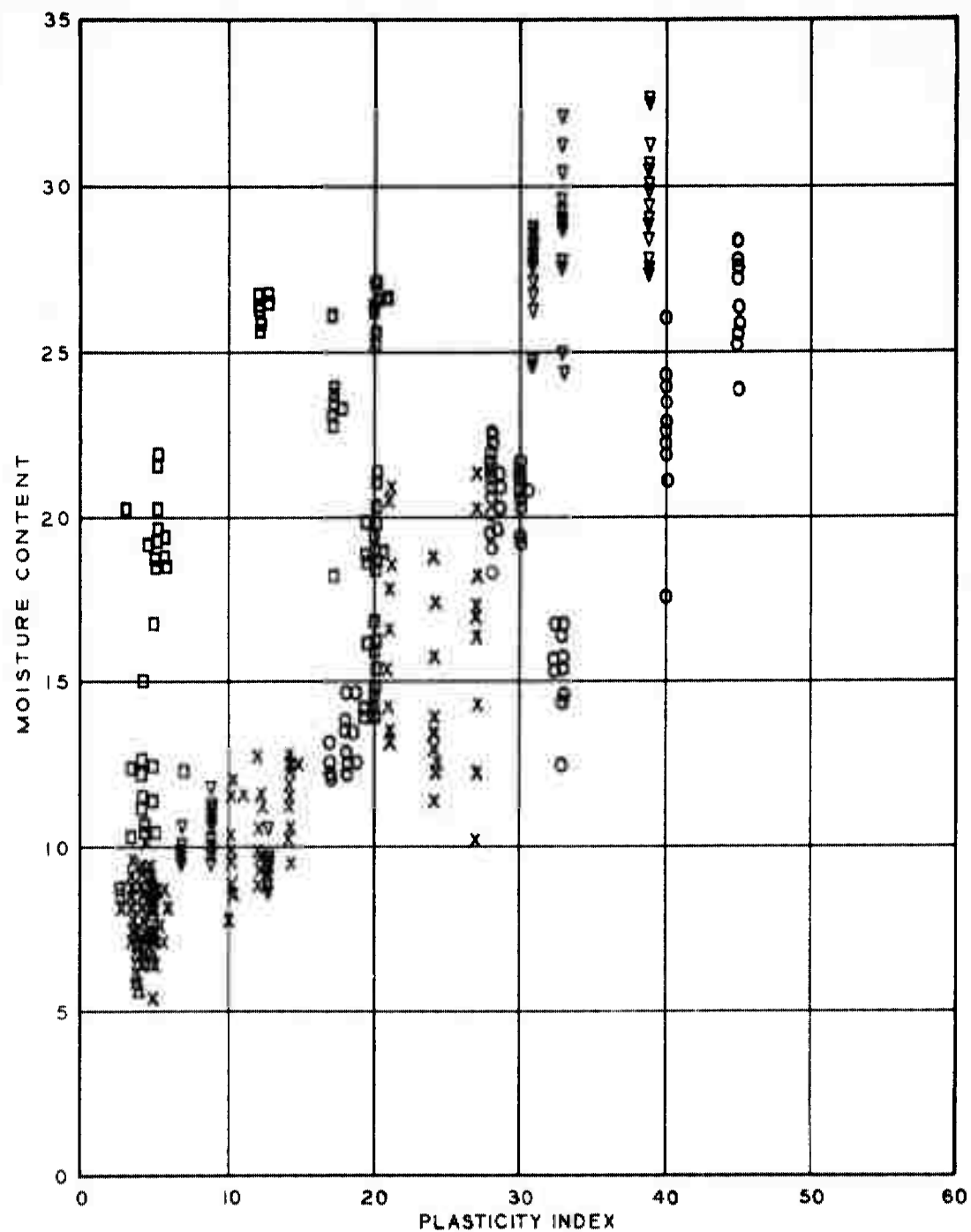
#### MOISTURE CONTENT VS PLASTICITY INDEX

NORMAL LOCATIONS  
BASE COURSE

R 032852-F

PLATE 30





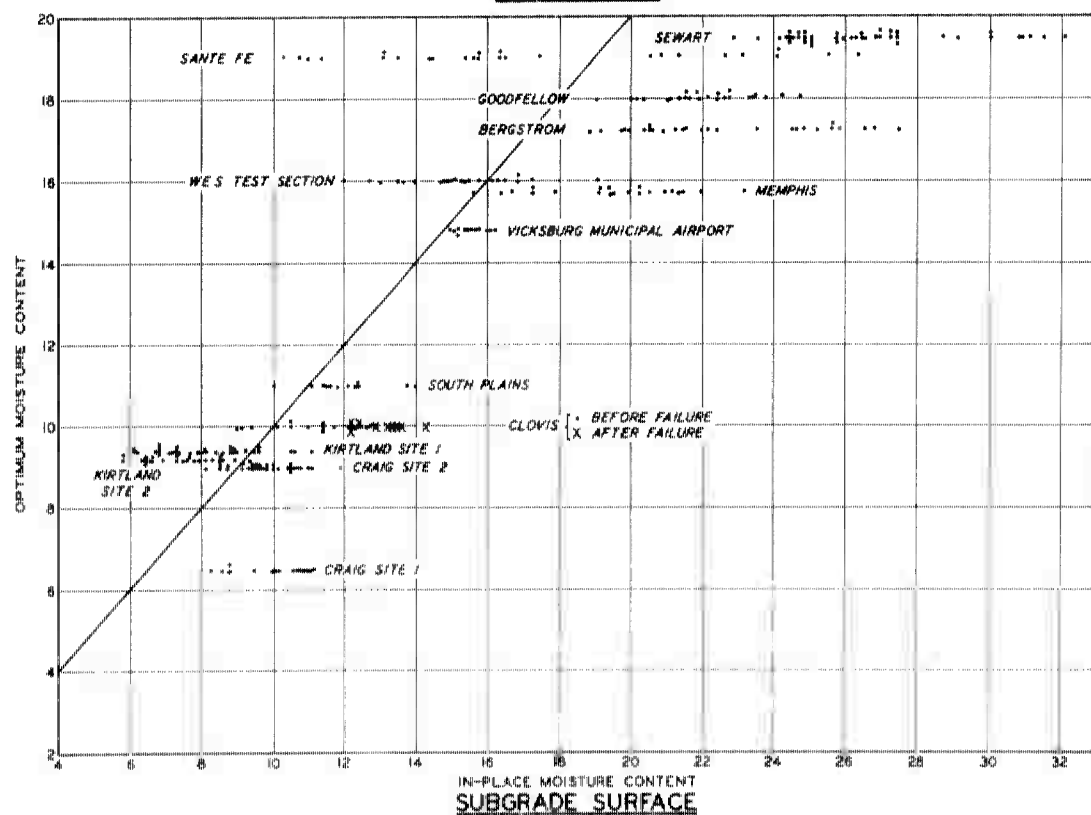
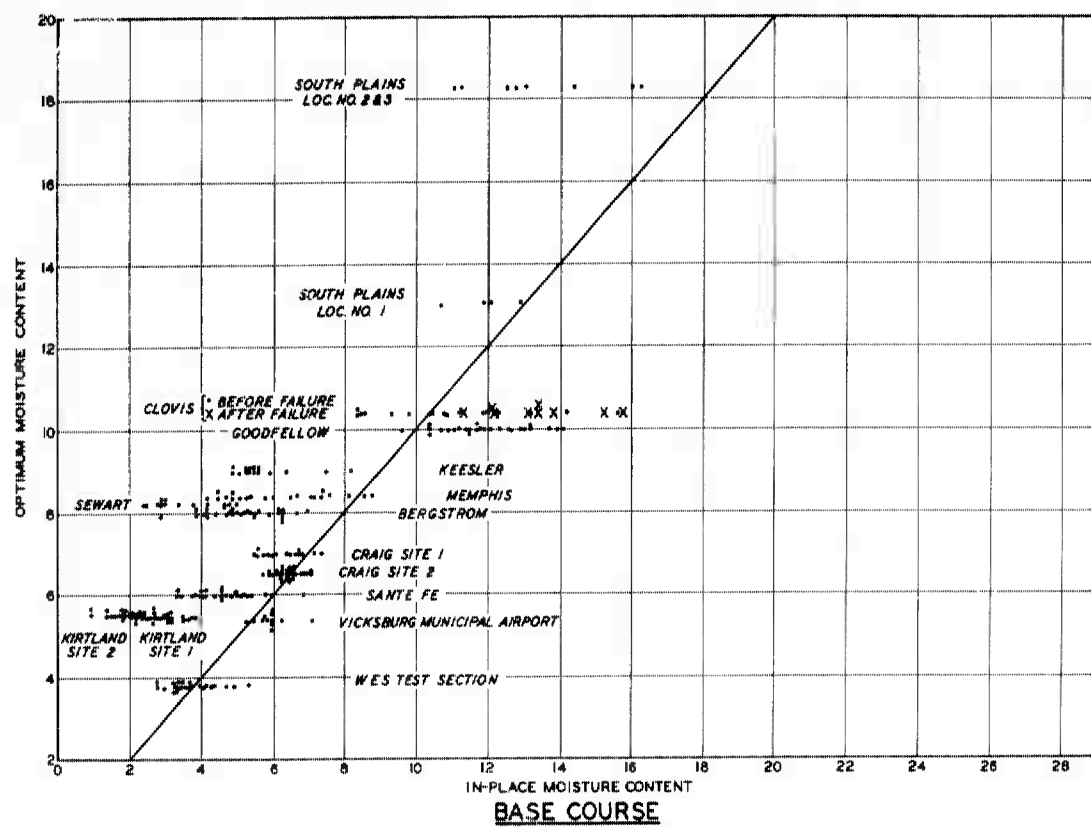
**LEGEND**

1945-1952		1952-1956
X	LOW RAINFALL ZONE	Δ
O	MEDIUM RAINFALL ZONE	
□	HIGH RAINFALL ZONE	▽

NOTE: THE VALUES SHOWN ARE AVERAGE MOISTURE CONTENTS FOR EACH PATTERN AT EACH TESTING

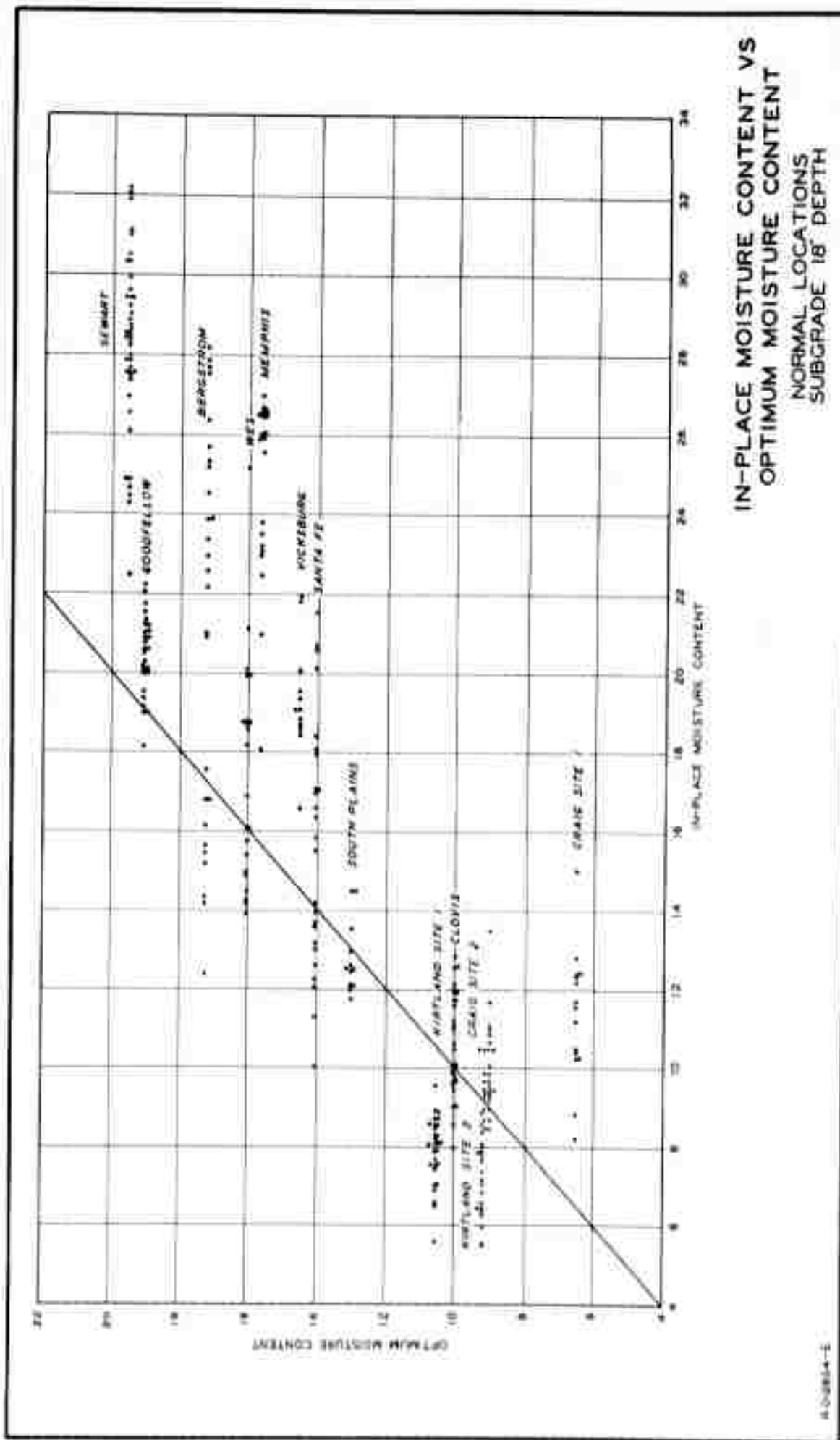
**MOISTURE CONTENT VS PLASTICITY INDEX**  
 NORMAL LOCATIONS  
 SUBGRADE-18" DEPTH

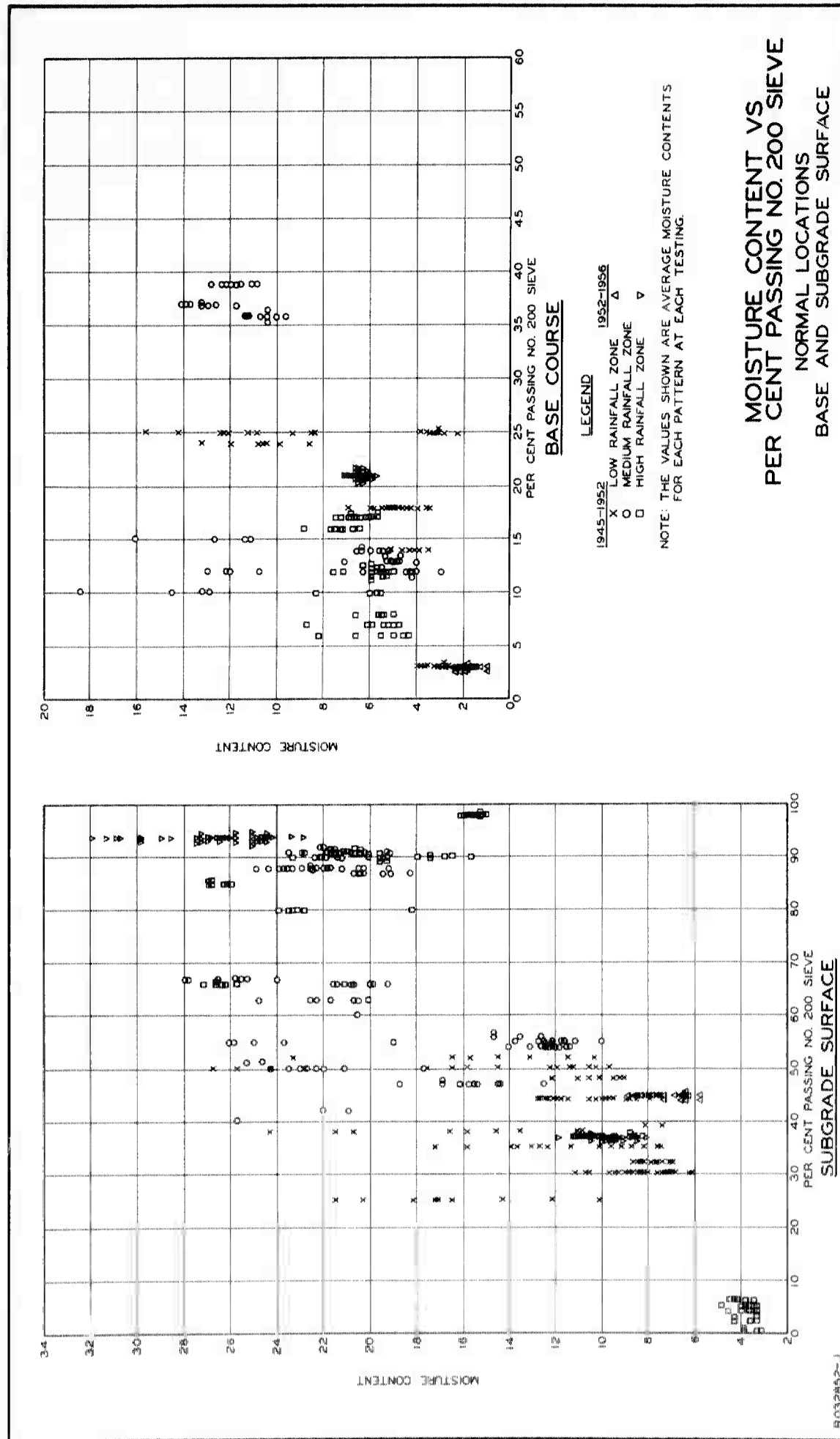
R 012654-B

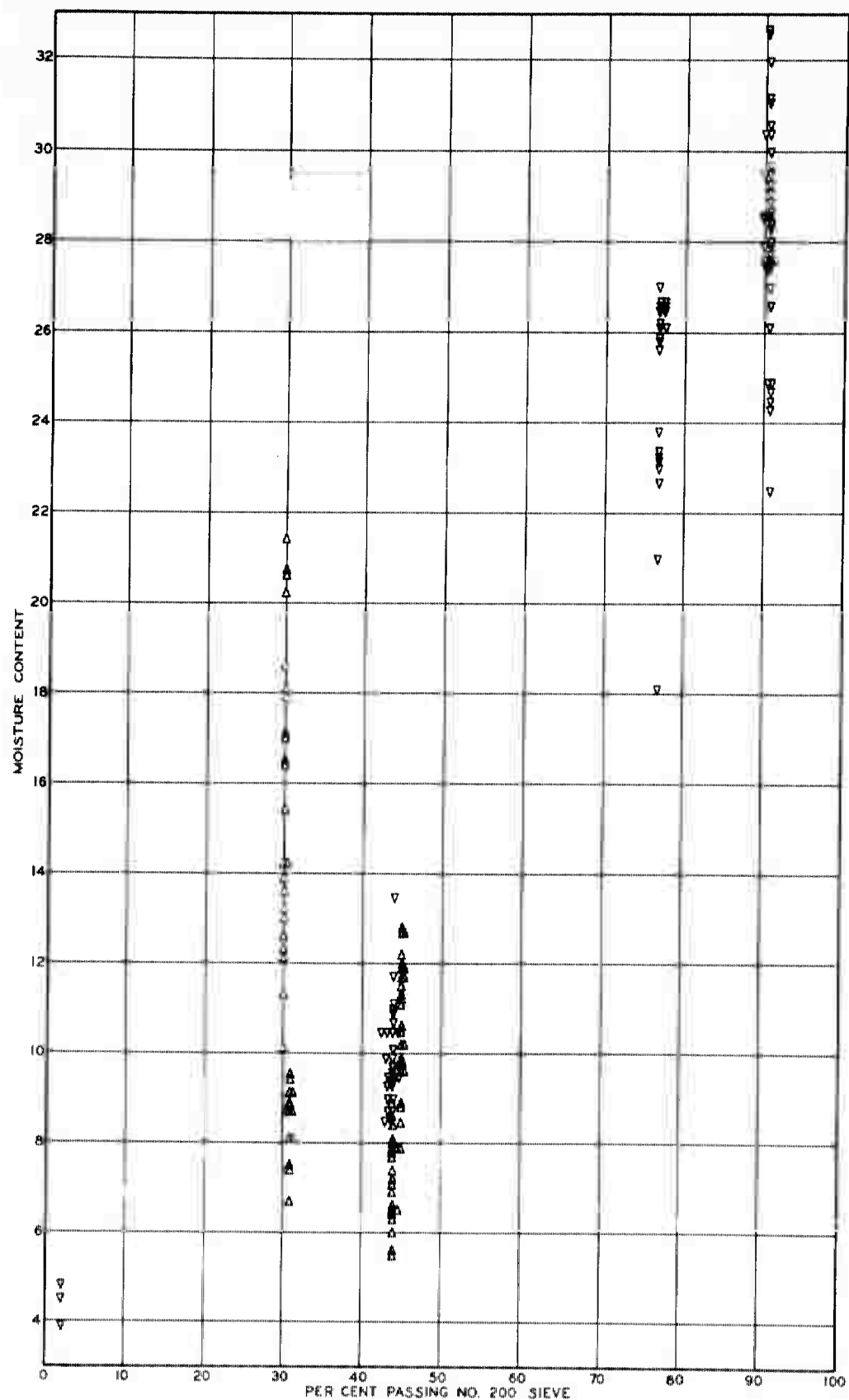


IN-PLACE MOISTURE CONTENT VS  
OPTIMUM MOISTURE CONTENT  
NORMAL LOCATIONS  
BASE AND SUBGRADE SURFACE

R 032852-L







**LEGEND**

1952-1958

△ LOW RAINFALL ZONE

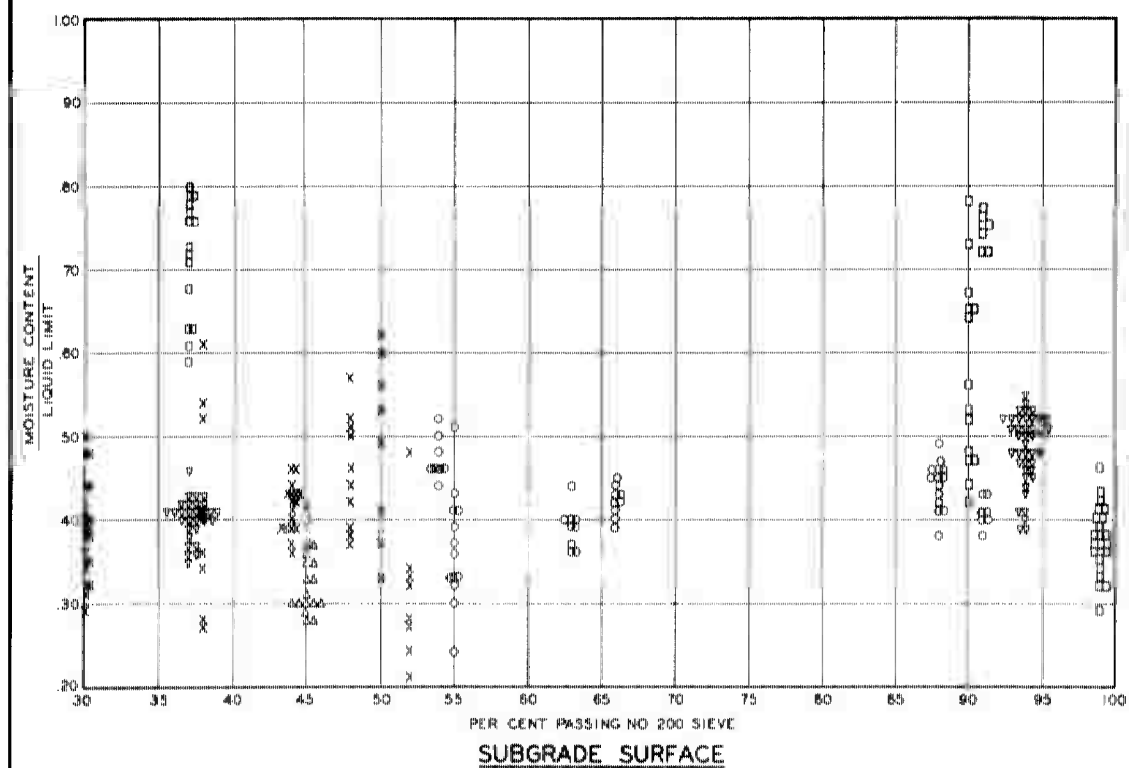
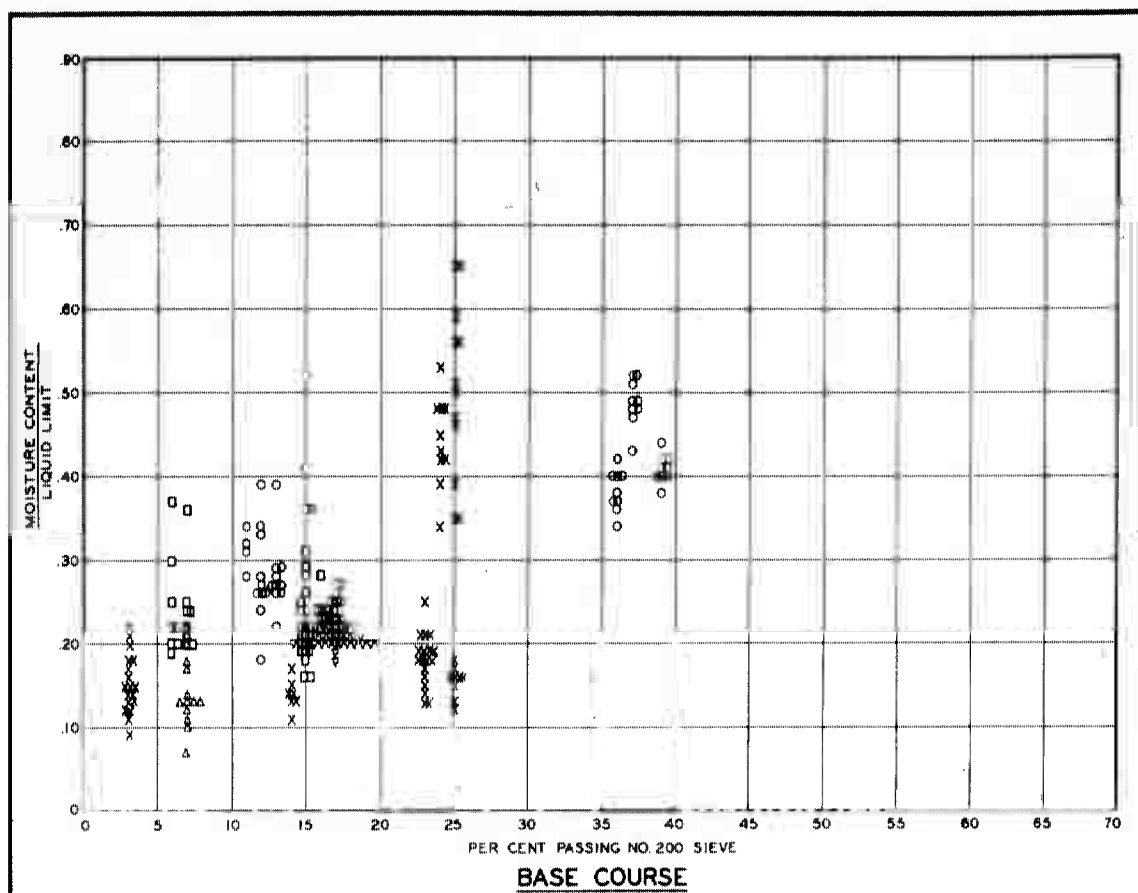
▽ HIGH RAINFALL ZONE

NOTE: THE VALUES SHOWN ARE AVERAGE  
MOISTURE CONTENTS FOR EACH  
PATTERN AT EACH TESTING.

R 0112156-C

**MOISTURE CONTENT VS  
PER CENT PASSING NO. 200 SIEVE**

**NORMAL LOCATIONS  
SUBGRADE 18-IN. DEPTH**



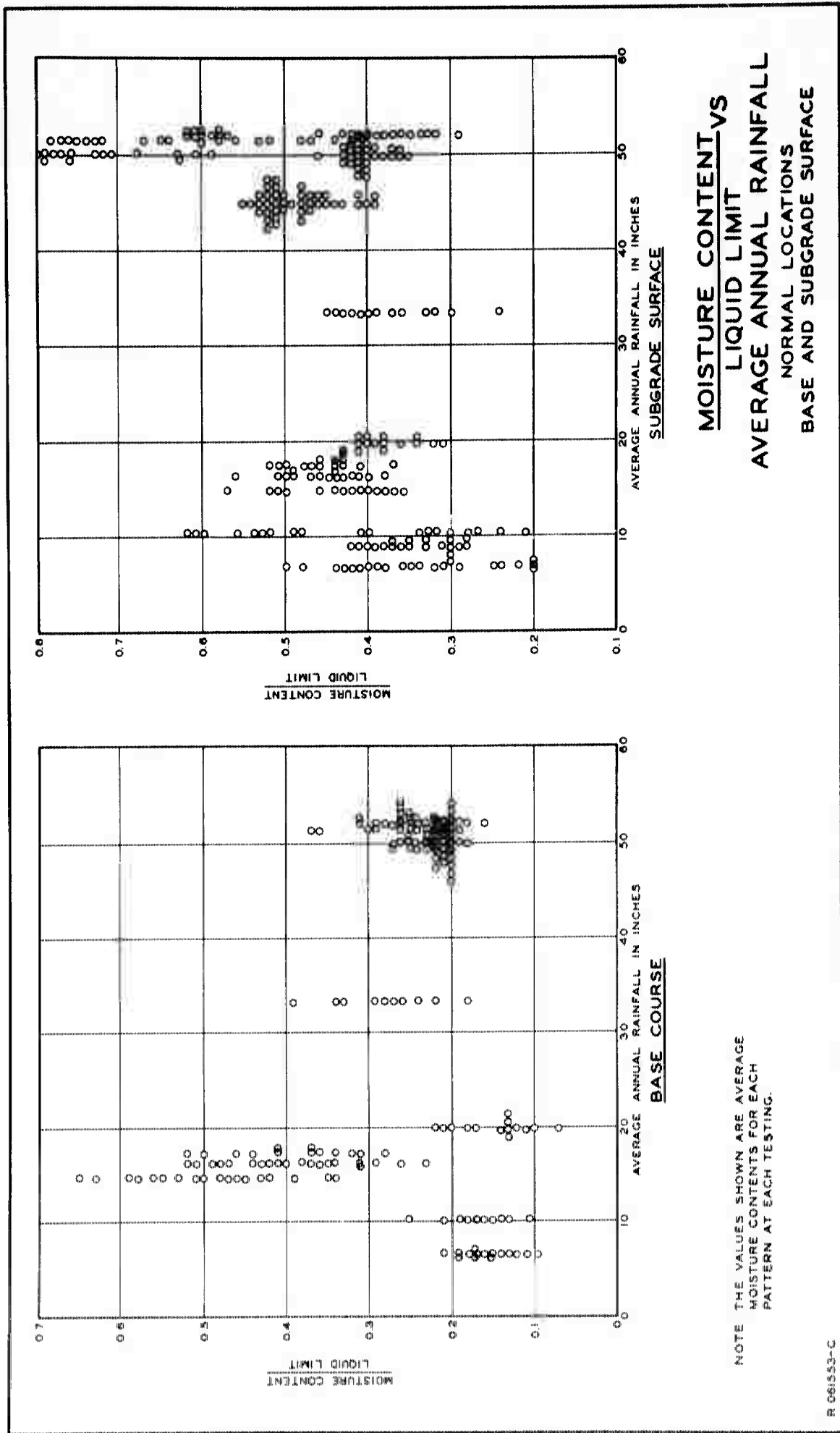
**LEGEND**

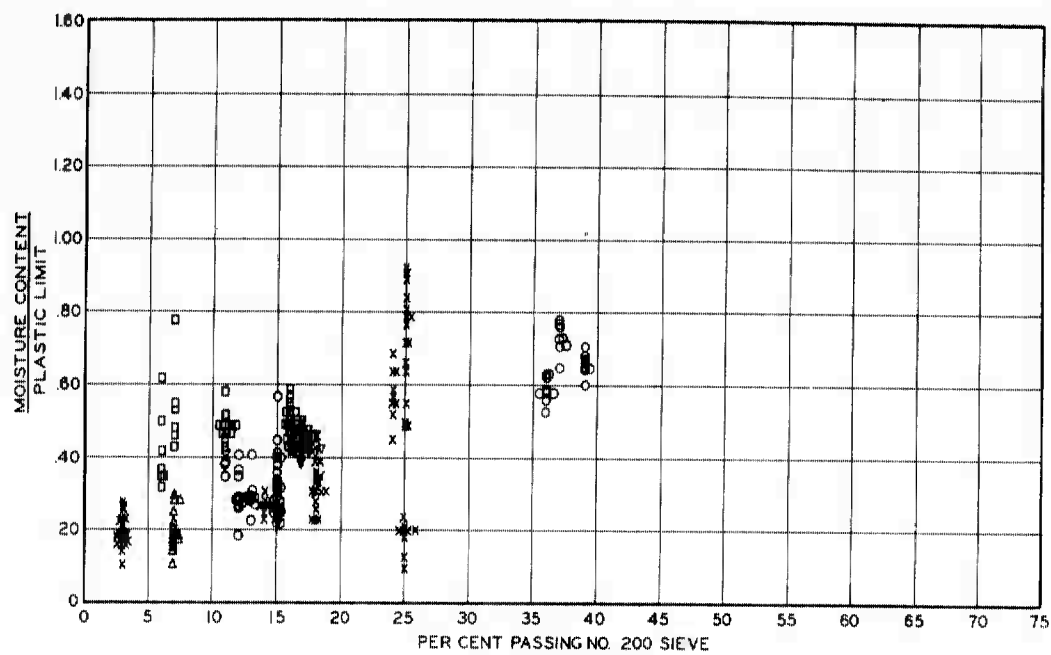
<p>1945-1952</p> <p>X LOW RAINFALL ZONE</p> <p>O MEDIUM RAINFALL ZONE</p> <p>□ HIGH RAINFALL ZONE</p>	<p>1952-1956</p> <p>Δ</p> <p>▽</p>
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NOTE: THE VALUES SHOWN ARE AVERAGE MOISTURE CONTENTS FOR EACH PATTERN AT EACH TESTING

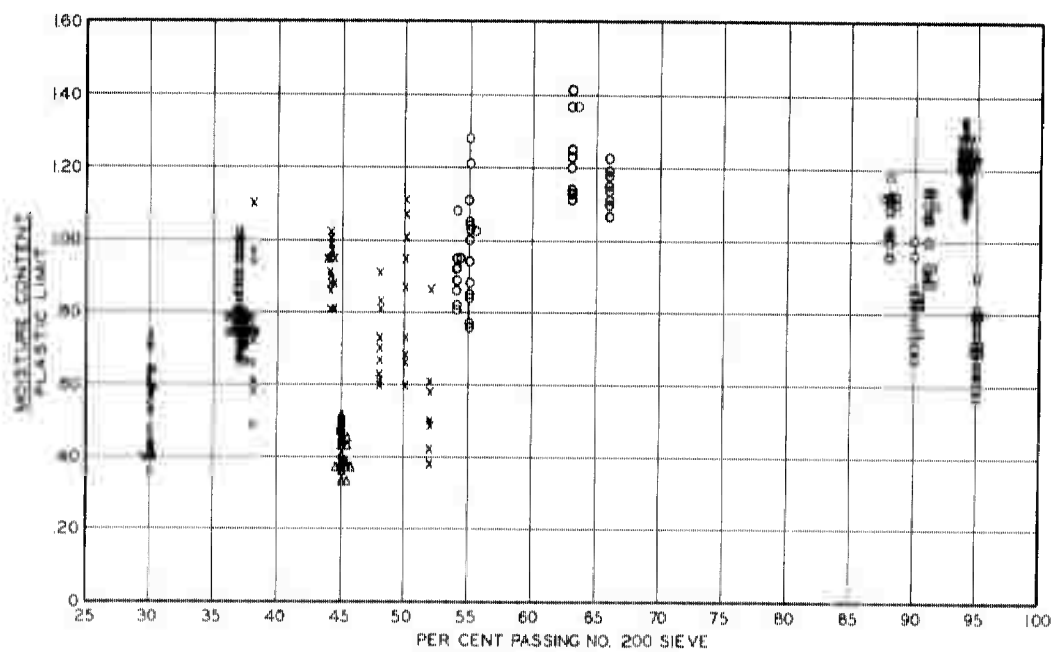
**MOISTURE CONTENT / LIQUID LIMIT VS PER CENT PASSING NO. 200 SIEVE**  
**NORMAL LOCATIONS**  
**BASE AND SUBGRADE SURFACE**

R 061533-G





BASE COURSE



SUBGRADE SURFACE

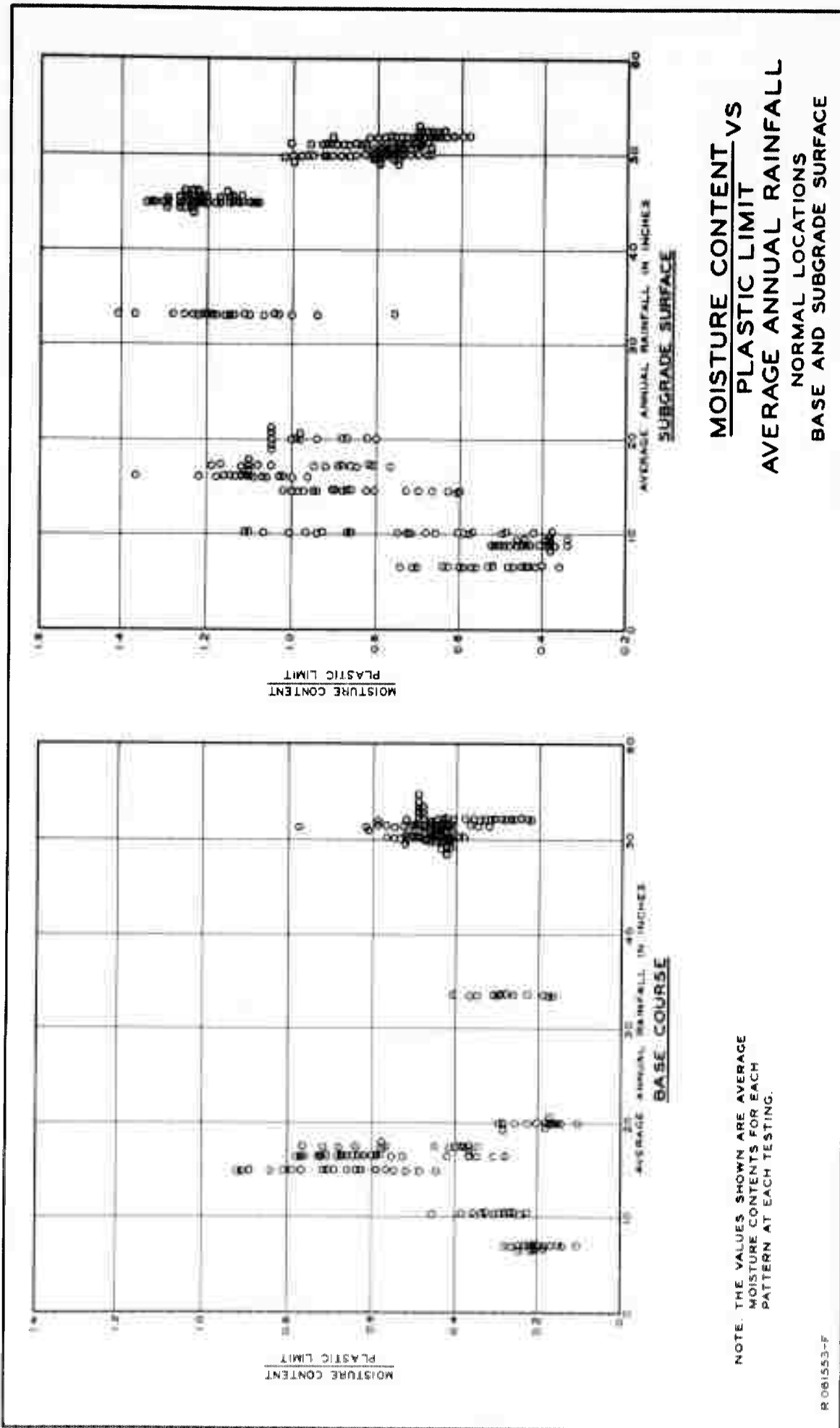
LEGEND

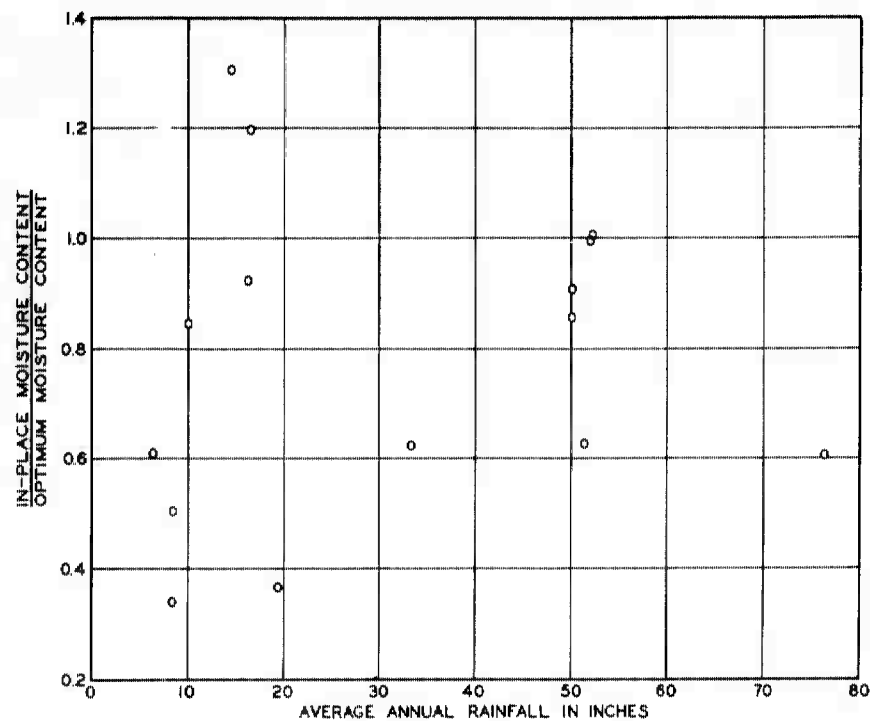
1945-1952	1952-1956
X LOW RAINFALL ZONE	Δ
O MEDIUM RAINFALL ZONE	
□ HIGH RAINFALL ZONE	▽

NOTE THE VALUES SHOWN ARE AVERAGE  
MOISTURE CONTENTS FOR EACH  
PATTERN AT EACH TESTING

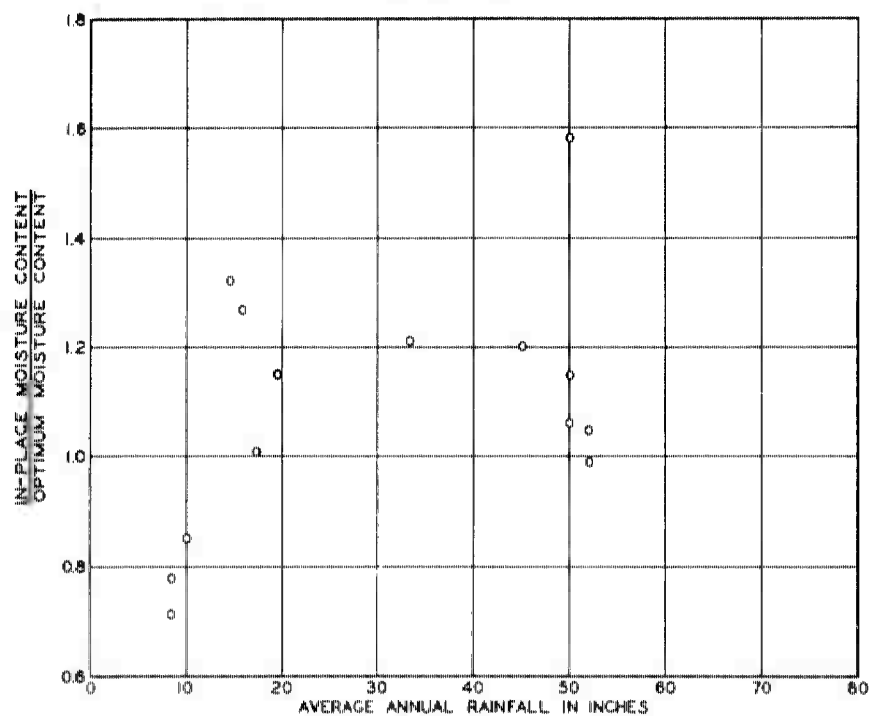
MOISTURE CONTENT  
PLASTIC LIMIT VS PER CENT  
PASSING NO. 200 SIEVE  
NORMAL LOCATIONS  
BASE AND SUBGRADE SURFACE

RD61553-0





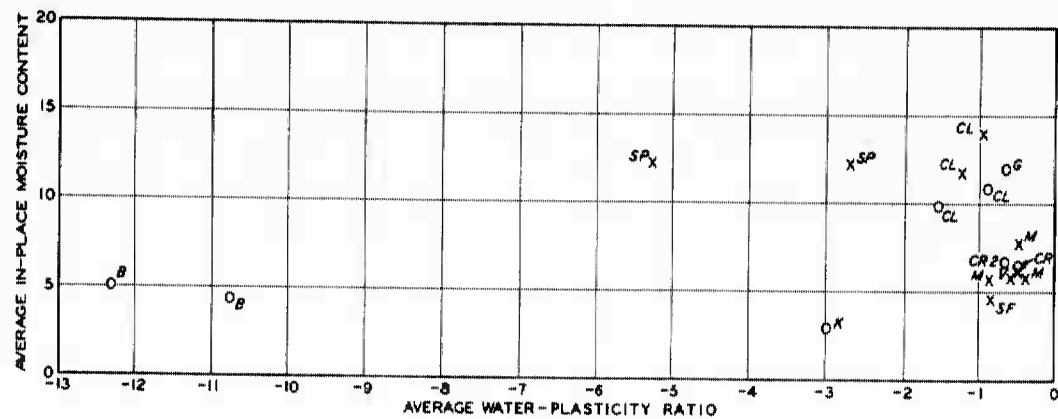
BASE COURSE



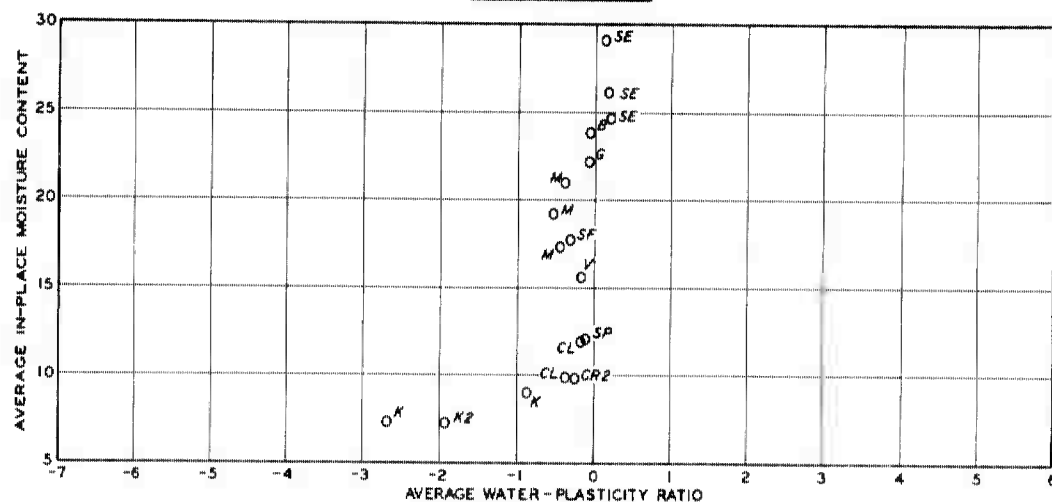
SUBGRADE SURFACE

MOISTURE CONTENT VS  
OPTIMUM MOISTURE  
 AVERAGE ANNUAL RAINFALL  
 NORMAL LOCATIONS, BASE AND  
 SUBGRADE SURFACE MODE VALUES

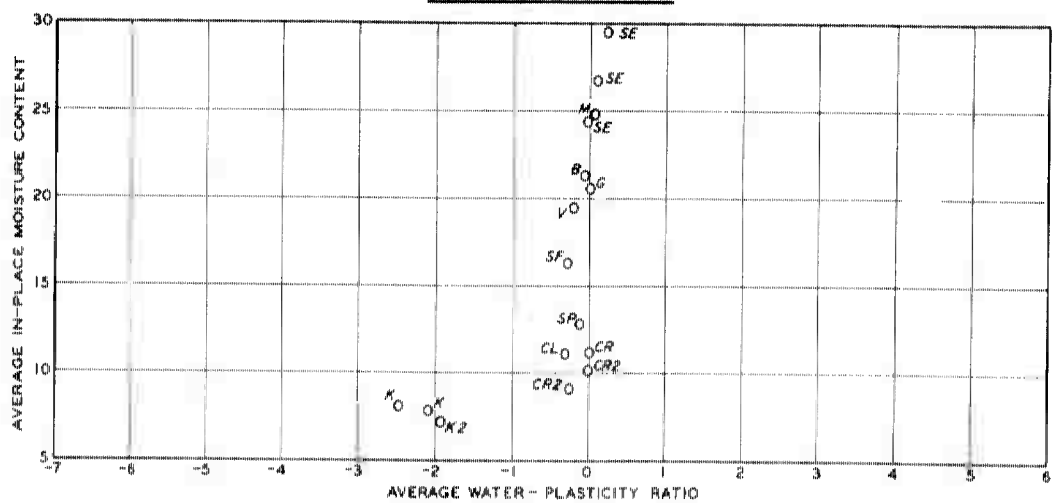
R 061553-E



### BASE COURSE



### SUBGRADE SURFACE



### SUBGRADE 18-IN. DEPTH

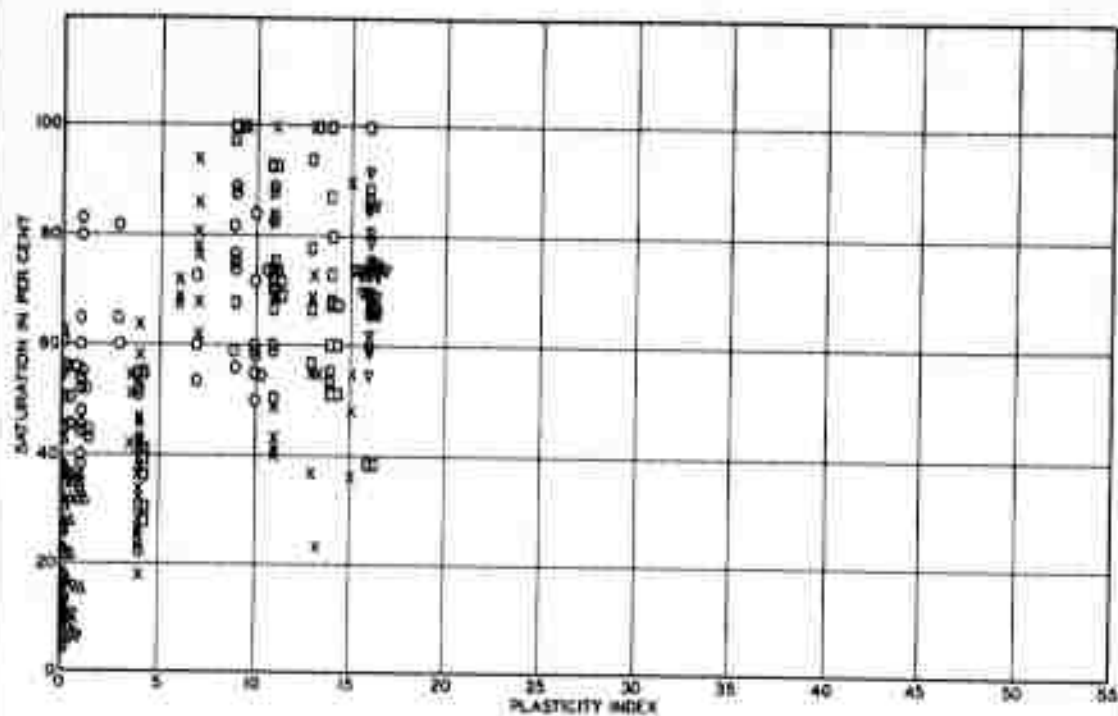
NOTE: WATER-PLASTICITY RATIO =  $\frac{\text{IN-PLACE MOISTURE CONTENT} - \text{PLASTIC LIMIT}}{\text{LIQUID LIMIT} - \text{PLASTIC LIMIT}}$

### LEGEND

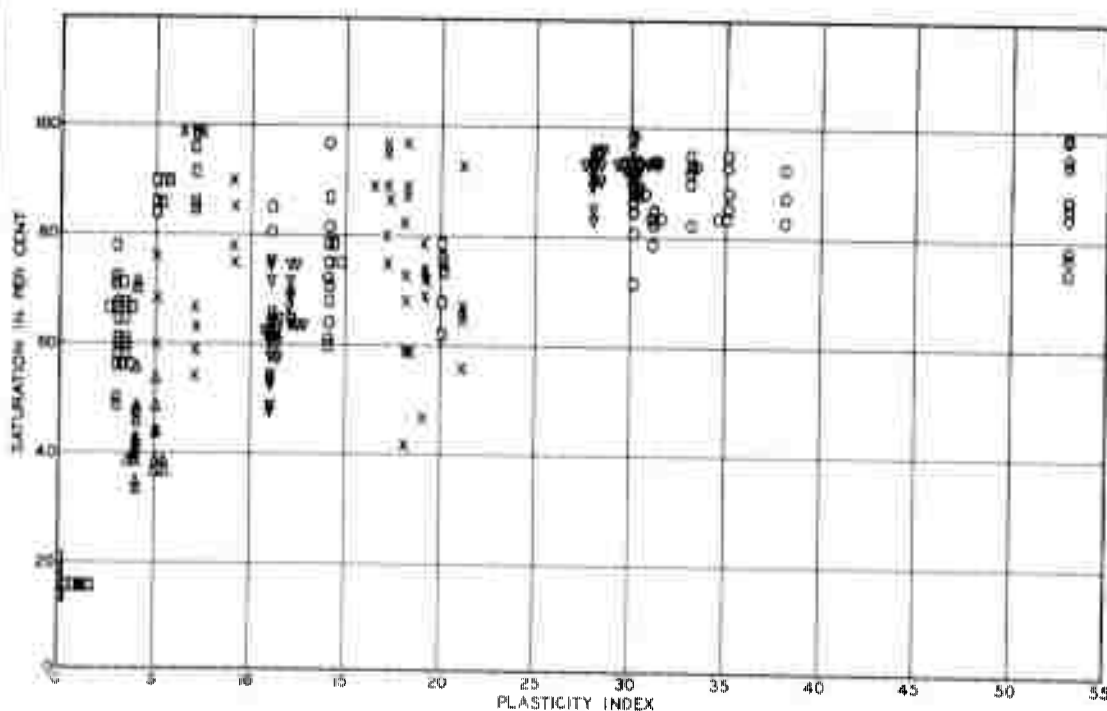
X	SHEAR FAILURE	M	MEMPHIS
O	SATISFACTORY	G	GOODFELLOW
SP	SOUTH PLAINS	CR	CRAIG
SF	SANTA FE	B	BERGSTROM
K	KIRTLAND	V	VICKSBURG
CL	CLOVIS	CR2	CRAIG SITE 2
K2	KIRTLAND SITE 2	SE	SEWART

IN-PLACE MOISTURE CONTENT  
VS WATER-PLASTICITY RATIO

IR032754-A



BASE COURSE



SUBGRADE SURFACE

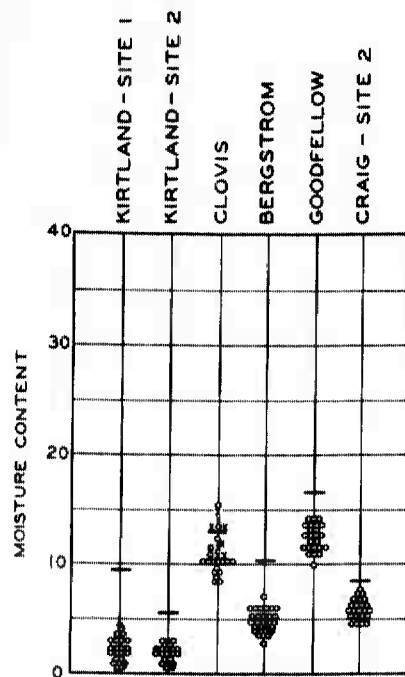
LEGEND

<u>1945-1952</u>		<u>1952-1956</u>	
X	LOW RAINFALL ZONE	Δ	
○	MEDIUM RAINFALL ZONE		
□	HIGH RAINFALL ZONE	▽	

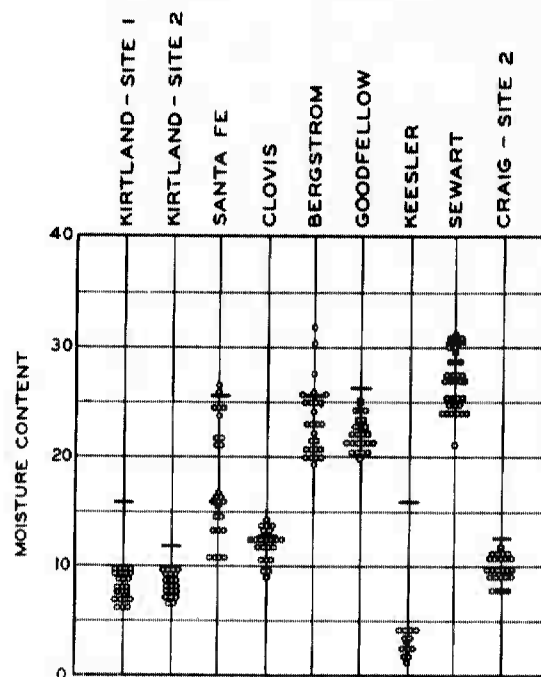
NOTE: THE VALUES SHOWN ARE AVERAGE DEGREES OF SATURATION FOR EACH PATTERN AT EACH TESTING

DEGREE OF SATURATION VS  
PLASTICITY INDEX  
NORMAL LOCATIONS  
BASE AND SUBGRADE SURFACE

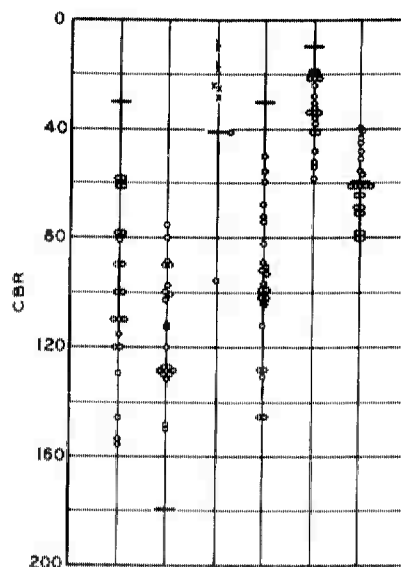
R033152-N



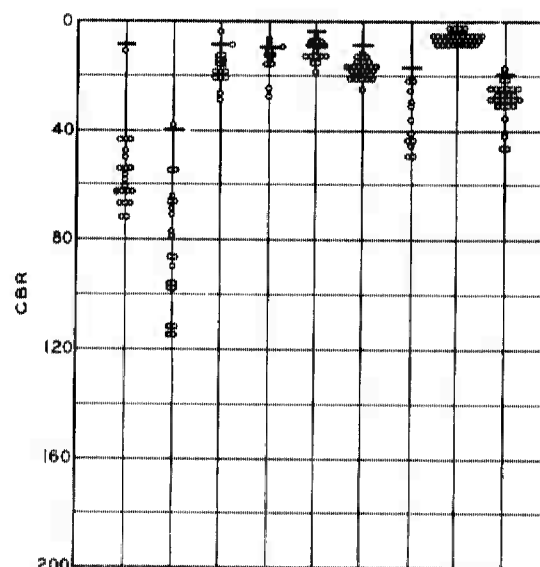
BASE COURSE



SUBGRADE SURFACE



BASE COURSE



SUBGRADE SURFACE

LEGEND

- LABORATORY-PREDICTED VALUE
- ° IN-PLACE VALUE
- x IN-PLACE VALUE AFTER BASE SHEAR FAILURE

LABORATORY VS IN-PLACE  
MOISTURE CONTENT AND  
CBR VALUES

NORMAL AND SHOULDER LOCATIONS  
BASE AND SUBGRADE SURFACE

R 021056-D

UNCLASSIFIED

UNCLASSIFIED